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BY J. P. LESLEY,

PROFESSOR OF GEOLOGY IN THE UNIVERSITY OF PENNSYLVANIA.

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1874.

210142

THE BROWN HEMATITE

IRON ORE BANKS

OF

THAT PART OF NITTANY VALLEY CALLED

WARRIOR'S MARK VALLEY

HALF MOON VALLEY

AND

SPRUCE CREEK VALLEY

IN

HUNTINGDON AND CENTRE COUNTIES

PENNSYLVANIA

OWNED BY

LYON, SHORB & CO., PITTSBURG, PA.

By J. P. LESLEY

PROFESSOR OF GEOLOGY IN THE UNIVERSITY OF PENNSYLVANIA

PHILADELPHIA
McCALLA & STAVELY, PRS., 237-9 DOCK STREET
1874

The Brown Hematite Ore Banks of Spruce Creek, Warrior's Mark Run, and Half Moon Run, in Huntingdon and Centre Counties, Pennsylvania, along the line of the Lewisburg, Centre County and Tyrone Railroad.

Preliminary Chapter.

The district under examination, with an area of about one hundred square miles, is bounded on the west by the Bald Eagle Mountain, on the east by Tussey Mountain, and on the south by the Little Juniata River, and the Pennsylvania Central Railroad.

The Huntingdon-Centre County-line crosses it transversely from mountain to mountain. The Huntingdon-Blair County-line follows the river.

Spruce Creek flows southward along the foot of Tussey Mountain. Its branches, Warrior's Mark Run and Half Moon Run, cross the country from Bald Eagle Mountain, along the foot of which their head waters flow Logan's Run flows at the foot of Bald Eagle Mountain into the Little Juniata River near Tyrone. See large Map.

The river and the two runs afford fine opportunities for three cross-sections, represented in figs. 1, 2 and 3. These sections have been photo-lithographed (like the map) to a very reduced scale for convenience of publication, but were carefully constructed on the same vertical and horizontal large scale, so that their geology may be relied on.

The map was plotted with great care from the survey notes of Mr Franklin Platt,* (as were also all the reduced local maps of the Ore Banks, figs. 8 to 44) and adjusted with almost no variation to the railroad survey maps in the office of that experienced and most reliable Civil Engineer, Mr. Leuffer, who located, constructed and has in charge the completion of the L. C. C. and T. R. R., to whose courtesy I am in this as in other cases, so largely and gladly indebted.

The map is drawn in ten foot contour lines, determined by aneroid observations, based on the spirit levels of the railway lines, preliminary and adopted. One set of aneroid observations was carried to the top of Tussey from Pennsylvania Furnace; the rest of the mountain being drawn in by rough trigonometrical observations from the Spruce Creek road. The gaps in its terrace are all properly placed and their characteristic features given: but slight variations in the almost dead level crest of the mountain could only be indicated. The survey of the Spruce Creek Valley was made rapidly and only for the purpose of assigning a proper value to its topographical features, a new township survey by a corps of odometer surveyors being the basis. Here a considerable adjustment had to be made, which renders this part of the map of no authority, as against careful future surveys. The adjustment affects the whole southeast corner of the map, viz.: the interval between the mouth of Warrior's Run and the river. It is none of it accurate. The rest of the map is very accurate and reliable.

---

*Formerly an Assistant on the U. S. Coast Survey.

Various former surveys of the Juniata were compared in plotting Mr. Platt's survey along the Pennsylvania Railroad, and all were found to be discordant in details, but the topographical features of the deeply eroded bed of the Little Juniata are portrayed with sufficient precision.

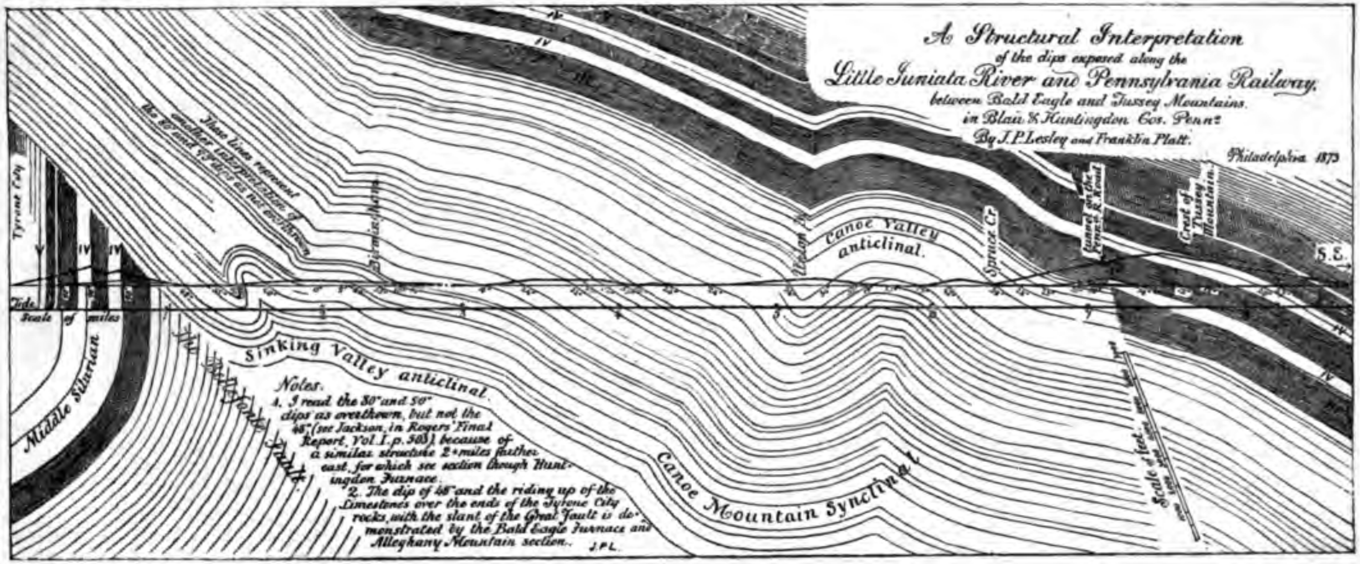
Time failed for a careful survey of the mouths of Canoe and Sinking Valleys south of the river. I leave these and the interesting synclinal mountain (Canoe Mountain) which separates them, for a future opportunity. Canoe Valley leads south into Morrison's Cove, a reconnoissance survey of which I made some years ago for the Pennsylvania R. R. Co., to determine the economical value and geological attitude of its brown hematite iron ores, the analogues of those to be described in this report.

Three sets of aneroid levels were carried to the top of the Bald Eagle Mountain, and two of these were continued to its western base, along which flows the Big and Little Bald Eagle Creeks, and runs the Bald Eagle (Tyrone, Bellefonte and Lockhaven) Railroad. A much more careful study of Bald Eagle Mountain than of Tussey Mountain had to be made; first, on account of the Great (Bellefonte or Tyrone Forge) Fault which runs along its east foot; secondly, on account of the vertical attitude of its rocks and the very irregular erosion to which it has therefore yielded; thirdly, on account of a deflection of trend, due to the little synclinal crimple shown in two of the Cross Sections; and fourthly, on account of the outcrops of fossil ore on its western slope. Yet, I should be glad to make a complete hypsometric projection of this very interesting mountain, with its dentated double crest, for scientific purposes. Its character is, however, well portrayed in my map and will tell the whole story to any geologist.

A second map (also reduced by photolithography from its original scale of 100 perches to the inch,) is appended to this report. It is a copy, corrected to date, of the land line map* of Lyon, Shorb & Co.'s ore and other lands in Huntingdon, Blair and Centre Counties, covering about 200,000 acres in the valley and on its two bounding mountains, and stretching westward beyond the Bald Eagle Creek to the coal measures on the crest of the Alleghany Mountain. It was impossible to transfer the numerous and complicated land lines of this map to my topographical map without concealing its features beneath a net work of irrelevant indications. I have gone even farther in my anxiety to show with unobstructed clearness the geology by the topography; I have abstained from introducing *local names* upon my map, trusting to the intelligence of those who consult it, guided by a small key map in its southeast corner, and by the descriptions I give of localities with reference to the numerous ore banks which are *numbered*. The key to the numbers will be found in the northeast corner

* The original is in the office of Mr. Lowrie, at Warrior's Creek, Huntingdon Co., Pa.

FIG. 1.


A Structural Interpretation
of the dips exposed along the
Little Juniata River and Pennsylvania Railway,
between Bald Eagle and Tussey Mountains,
in Blair & Huntingdon Cos. Penn?
By J. P. Lesley and Franklin Platt.
Philadelphia 1873
Tyrone City
IV
IV
IV
Tide
Scale of miles
Middle Silurian
These lines represent another interpretation of the 30° and 50° dips as not overthrown
Birmingham
Sinking Valley anticlinal.
Fault.
Notes.
1. I read the 30° and 50° dips as overthrown, but not the 48° (see Jackson, in Rogers' Final Report, Vol. I. p. 503) because of a similar structure 2+ miles farther east, for which see section through Huntingdon Furnace.
2. The dip of 48° and the riding up of the Limestones over the ends of the Tyrone City rocks, with the slant of the Great Fault is demonstrated by the Bald Eagle Furnace and Alleghany Mountain section.
J. P. L.
Union Fe
Canoe Valley anticlinal.
Canoe Mountain Synclinal.
Spruce Cr.
Tunnel on the Penn. R. Road
Crest of Tussey Mountain.
S. E.
Scale of feet.
IV
IV

of the map. The numbers follow rudely the ore belts, but not on any strictly scientific principle; they are arranged for the convenience of the reader.

A third map, heliotyped from a large original study of Brush Mountain (Bald Eagle Mountain continued southward across the Little Juniata River) is also appended, to show the outcrop of the Fossil Ore on that part of the property which extends in that direction. But the description of these Upper Silurian Fossil Ores must be kept separate from my discussion of the Lower Silurian Brown Hematites, or Limonites of the Nittany Valley.

GENERAL GEOLOGICAL CONSIDERATIONS.

The country specially examined in this report covers outcrops of the following geological formations, designated by the numbers of the old Pennsylvania State Survey, and the names given them by English and by New York Geologists.

No. V.	Upper Silurian.	Clinton Red Shale.	[illegible]
No. IV.	Upper, white. Middle, red,	Medina Sandstone.	[illegible]
	Lower, grey.	Oneida Conglomerate.	[illegible]
No. III.	Lower Silurian.	Hudson River Slate.	Slate
No. II.	Lower Silurian.	Trenton Limestone. Black River Limestone. Birdseye Limestone. Chazy Limestone. Calciferous Sandstone.	[illegible] [illegible]
No. I.	Lower Silurian.	Potsdam Sandstone.	[illegible]

The Iron ore horisons described in this report are as follows:

In No. V. The upper or soft fossil ores.
The lower or hard fossil ore.

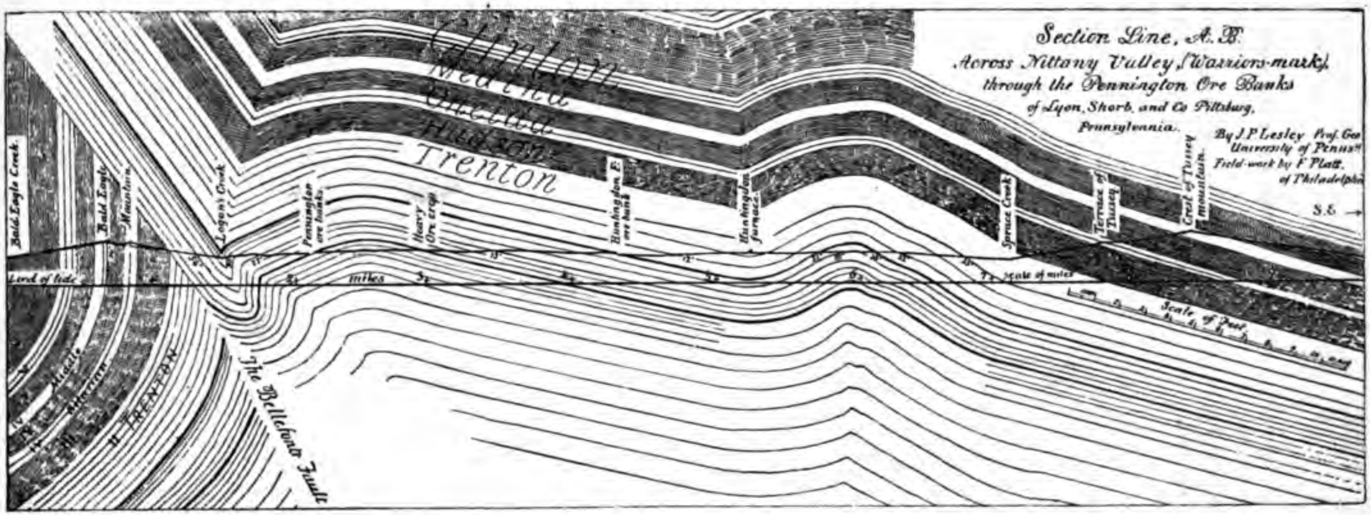
In No. II. The first horison at the bottom of the Trenton Limestone: Pennsylvania Furnace and Spruce Creek ores, and ores of Cale Hollow.

In No. II. The second horison: the whole Dry Hollow Range of ore banks, including Huntingdon Furnace and Dorsey Bank.

In No. II. The lowest horison, far above the top of the Calciferous: the Warrior's Mark and Lovetown Range and the Pennington Range.

The dip of the rock, of the whole country exhibited on the map, from the foot of Bald Eagle Mountain to the crest of Tussey, is towards the S. S. E., with one or two undulations of no great moment. This is plainly shown by the three cross sections, figs. 1, 2, 3.

FIG. 2.


Section Line, A. B.
Across Nittany Valley, (Warriors-mark),
through the Pennington Ore Banks
of Lyon, Shorb, and Co Pittsburg,
Pennsylvania.
By J. P. Lesley Prof. Geo
University of Penns.
Field-work by F. Platt,
of Philadelphia
S.E. →
Bald Eagle Creek
Bald Eagle
Mountain
Logan's Creek
Pennington ore banks
Heavy Ore crop
Huntingdon F. ore bank
Huntingdon furnace
Spruce Creek
Terrace of Tussey
Crest of Tussey mountain
Clinton
Medina
Oneida
Hudson
Trenton
Middle
Silurian
II TRENTON
The Bellefonte Fault
Level of tide
miles
Scale of miles
Scale of Feet

A great fault runs along the foot of Bald Eagle Mountain, and on the west side of this fault the same formations are seen descending vertically. They then curve sharply, and pass horizontally N. Northwestward under the Alleghany Mountains, as shown in diagram section fig. 4.

This diagram section is constructed from the dips of the Upper Silurian, Devonian and Coal Measure rocks, observed on a survey of the road from Bald Eagle Furnace up Emigh's run and Laurel Creek to the crest of the Alleghany Mountain. The measurement of the curves of the different layers of this upturned mass, taken at every thousand feet, as shown in the diagram, result in giving a slope of 50° to 54° to the bassett edges of the broken mass.

It is evident that the upslide of the other section of the broken mass has conformed to this slope, and that the uniform dip of 54° ± observable for miles along the S. S. East foot of Bald Eagle Mountain (as represented in Juniata Section, and Sections AB and CD) is perfectly explained by the diagram.

This is the first time, I believe, a solution of this difficult problem in structural geology has been reached; and its bearings upon similar phenomena attending upthrow-faults and broken anticlinals in other regions will be noticed by geologists.

The theoretical deductions from this solution are important.

It proves that the original fault was in a vertical plane, and not on a slant.

It proves that the lower Silurian Limestone mass has ridden upon this slope to a considerable height, probably several miles, in the air above the present surface.

It illustrates the great erosion of the country, amounting to *thousands of cubic miles* of earth crust, including the coal measures (which are preserved on Broad Top, 20 miles to the southeast,) and gives us the source of the Cretaceous and Tertiary deposits of New Jersey and Delaware.

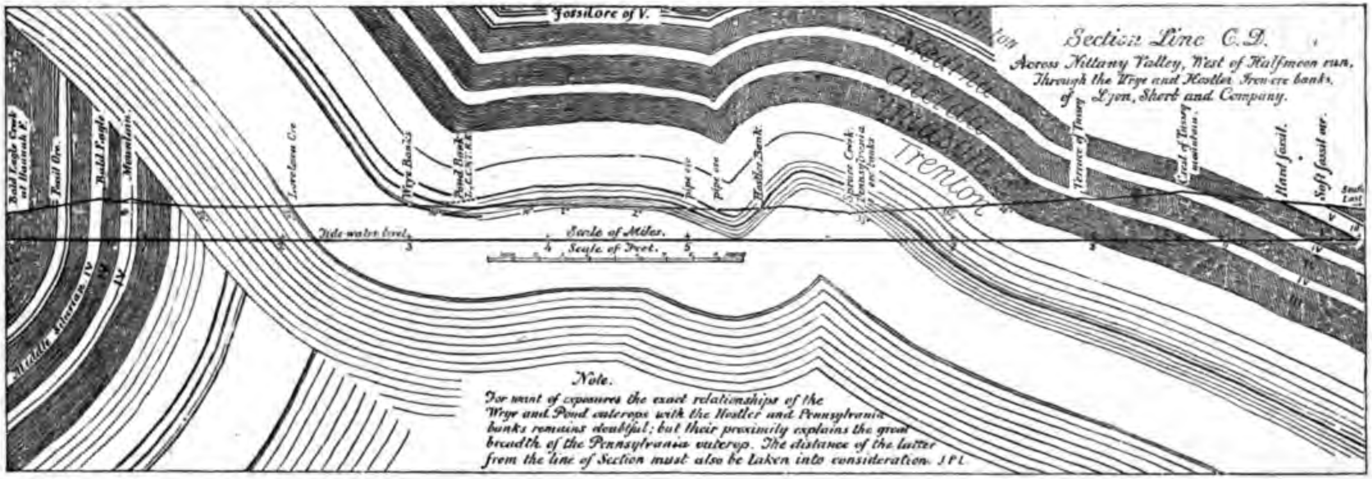
It leads me even to suspect the existence of a subterranean range of Laurentian Mountains (with their usual magnetic iron ores) at the bottom of the fault; this range determining the line of fracture.

It accounts for the general S. S. E. dip across the whole valley, Tussey Mountain, and as far as Huntingdon.

It assures us that the brown hematite ore beds of the district studied in this report belong to rocks of different ages, and are ranged in parallel belts according as the formations which carry them descend successively (S. S. Eastward,) beneath the present surface.

It confirms the opinion that the quantity of ore in these belts is not a local accident at each of the ore banks, but bears a fixed relation and proportion to the outcrop run of the ore-bearing limestones, lengthwise of the valley; and, therefore, that any estimate of the quantity of ore we may make by examining the diggings, must fall short of the actual quantity of ore to be mined in future years in this valley.

FIG. 3.



Section Line C.D.

Across Nittany Valley, West of Halfmoon run,
Through the Wrye and Hostler Iron-ore banks,
of Lyon, Short and Company.

Note.

For want of exposures the exact relationships of the Wrye and Pond outcrops with the Hostler and Pennsylvania banks remains doubtful; but their proximity explains the great breadth of the Pennsylvania outcrop. The distance of the latter from the line of Section must also be taken into consideration. J P L

The *original source* of the brown hematite iron ores of our Lower Silurian limestone valleys has been speculatively sought for without sufficient investigation in the field; and much practical mischief has resulted from the errors promulgated. Most persons have looked upon them as accidental and local inwashes from unknown sites. Some have more systematically defined them as a residual precipitate from the disseminated iron-sand grains of the surrounding Middle Silurian mountain rocks during their erosion.

All such vague speculations might have been avoided had the results of Dr. R. M. S. Jackson's survey of the Nittany Valley ore beds in 1838 or 1839 been published by himself. As assistant on the geological survey of Pennsylvania he obtained the data necessary for concluding, at that early day, that they were deposits *in loco originali*, of the iron (as hydrated peroxide) set free from the limestone or dolomite rocks during their gradual erosion and dissolution.

I have myself, during the last twenty years, had ample opportunities for arriving independently at the same conclusion; and an intelligent study and comparison of the aspects of the ores and rocks in our iron ore banks will, I think, satisfy any good geologist in the same sense.

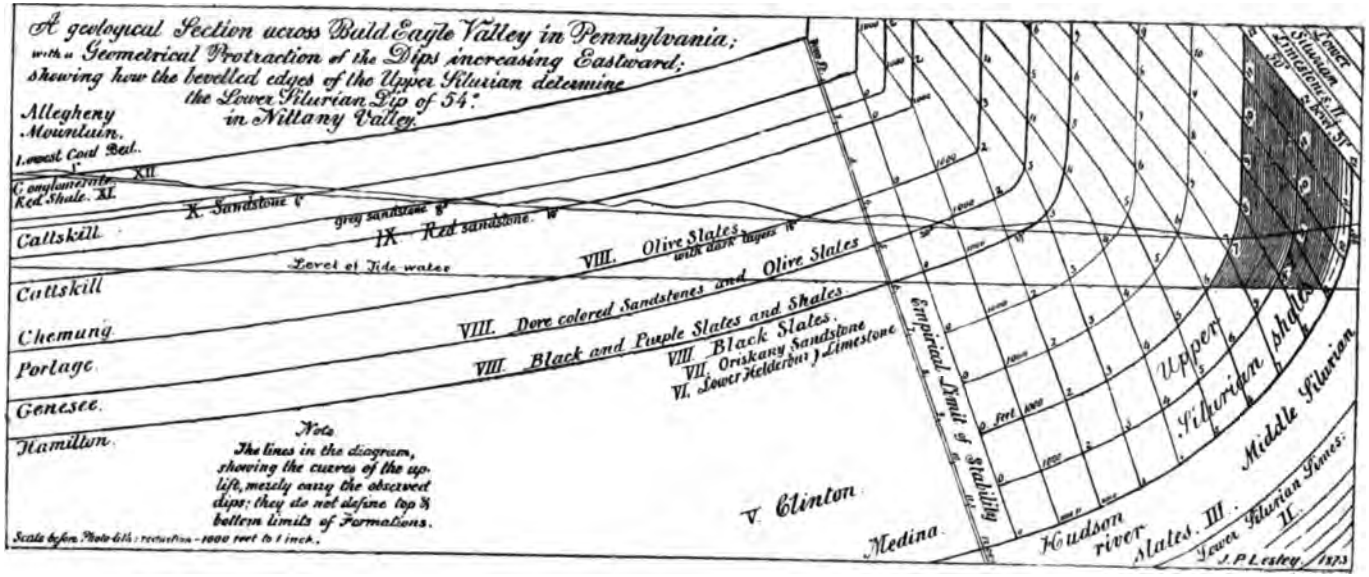
The precise *modus operandi* of the process is not yet well understood; for it involves chemical considerations not thoroughly worked out. But a general statement of the operation can be made without risk of serious error.

The rocks of the Lower Silurian Age were originally sea-muds, composed of rounded grains of dolomite (derived from previously existing Laurentian Land), cemented together with a paste of carbonate of lime Some of the beds consisted also of rounded grains of quartz. Some of the layers were nearly pure carbonate of lime. All contained a larger or smaller percentage of iron, lead, zinc and other metals, precipitated either chemically, or by the agency of organic beings, from the solutions of their carbonates, chlorides, &c., in the river-and sea-waters. The orderly explanation of all the chemical and organic features of this complicated operation is still to be given to the scientific world. But all will agree that the general character of the calcareo-ferruginous muds, the sediments of that early geological age must have been much as above described.

During the long Upper Silurian, Devonian and Carbiniferous Ages, these Lower Silurian sediments were buried to a depth of over 16,000 feet, beneath the later sediments. They remained wet. Their great depth raised their temperature $16{,}000 \div 50 = 320^{\circ}$ Farenheit's thermometer: which added to the mean temperature of the surface, would keep them under the influence of a moist heat of nearly 400° F. through what to man is a small eternity of time.

Dr. Genth's discovery of the amorphous or gelatinous condition of a part of their silica is thus explainable. Varied reactions must have ensued. The carbonates of lime and magnesia combined as dolomites,

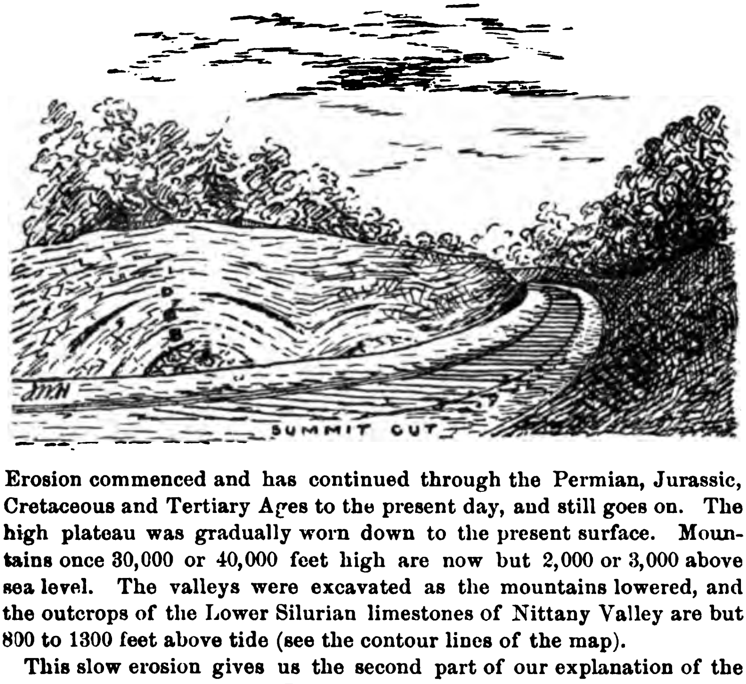
FIG. 4.


A geological Section across Bald Eagle Valley in Pennsylvania;
with a Geometrical Protraction of the Dips increasing Eastward;
showing how the bevelled edges of the Upper Silurian determine
the Lower Silurian Dip of 54°
in Nittany Valley.
Allegheny Mountain.
Lowest Coal Bed.
XII
Conglomerate.
Red Shale. XI.
X. Sandstone
grey sandstone
IX. Red sandstone.
Catskill.
Level of Tide-water
VIII. Olive Slates, with dark layers
Catskill
VIII. Dove colored Sandstones and Olive Slates
Chemung.
VIII. Black and Purple Slates and Shales
Portage.
VIII. Black Slates.
VII. Oriskany Sandstone
VI. Lower Helderberg Limestone
Genesee.
Hamilton.
Note
The lines in the diagram, showing the curves of the uplift, merely carry the observed dips; they do not define top & bottom limits of Formations.
V. Clinton
Medina
Empirical Limit of Stability
Upper Silurian shales
Middle Silurian
Hudson river Slates. III.
Lower Silurian Limes. II.
Lower Silurian Limestone II.
50°
Level 51°
feet 1000
Scale before Photo-lith: reduction - 1000 feet to 1 inch.
J. P. Lesley. 1875

which in part crystallized in rhombohedral crystals, the forms of which we now see, in the outcrops, emptied by dissolution. The silica hardened (without crystallizing) around these rhombs, so that we see the same cavities in it. The iron became peroxydised as *fibrous* hematite and the silica can be obtained by dilute nitric acid also *in the same fibrous form.* All this points to the first formation of the iron ore while the rocks were still at a great depth, wet and soft and warm.

But at the end of the coal era the Middle States rose from the waves and have never been covered by the ocean since that time. The edges of the Bellefonte Fault stood as a mountain range as high as the Alps (see Fig. 4), and the backs of some of the great anticlinals of Pennsylvania must have formed plateaus then as high as Thibet and Bootan are now.

FIG. 5.



Erosion commenced and has continued through the Permian, Jurassic, Cretaceous and Tertiary Ages to the present day, and still goes on. The high plateau was gradually worn down to the present surface. Mountains once 30,000 or 40,000 feet high are now but 2,000 or 3,000 above sea level. The valleys were excavated as the mountains lowered, and the outcrops of the Lower Silurian limestones of Nittany Valley are but 800 to 1300 feet above tide (see the contour lines of the map).

This slow erosion gives us the second part of our explanation of the brown hematite iron ores. It explains the innumerable caverns and sink holes and dry hollows of this Nittany and other limestone valleys. It leads us to expect to find traces of such caverns and widened fissures and sink holes of the last preceding age, filled up with a wash of clay, sand, and iron ore from outcrops lately existing not far above the outcrops which run along the present surface.

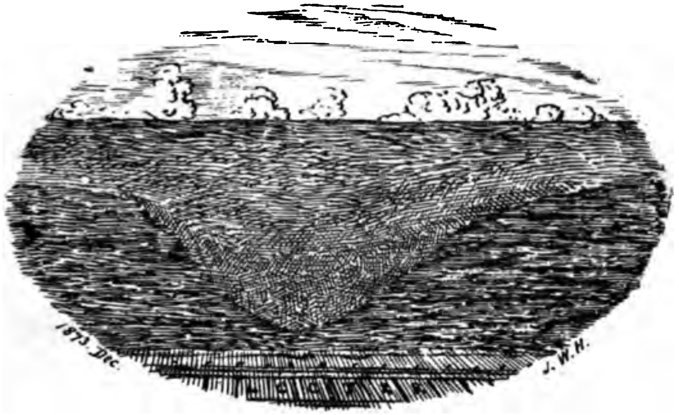
The erosion now still going on, and the special activity of the last or glacial age, may very well explain that outspread of surface wash-ore which makes so large a feature of the case. It may also explain the corrugations of the clay and ore strata in these superficial wash-ore deposits as represented in Figures 5, 6, 7 ; the localities pictured being on the line of the railroad near the East Pennington Ore Banks.

Thus the different theories in vogue among our iron men are harmonised. Each theory has its own basis of truth, its own set of facts, but does not embrace all the phenomena.

Those who contend that the brown hematites lie in pockets are correct; but they must confine the assertion to that part of the ore which now occupies former caverns and fissures and sink-holes.

Those who contend that the brown hematites are surface washes caught by the accidental variations of the earth's surface, are correct ; but they must limit the application of their theory to banks which show rolled gravel and rolled ore, and a confused and mingled mass of ore and sand and clay.

Fig. 6.

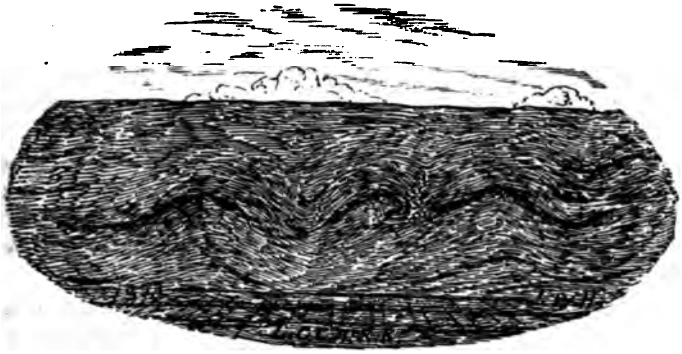

1873. Dec.
J. W. H.

Summit Cut, in siena-colored Wash-Ore, exhibiting erosion (?) & débris of pulverized Calcif: S. S.

A third view is equally correct and much more important. It must be accepted as probable, that in spite of later movements, and in addition to cavern-deposit ores, and surface-wash ores, there are interstratified beds of brown hematite, still in their original places, although not in their original condition, descending with the general slope of the formations between undissolved limestone, dolomite and sandstone rocks to undetermined depths, and ranging lengthwise of the district, so that rows of ore-banks can be and have been opened in continuous belts of many miles length, and on continuous outcrops of ore ground of every conceivable variety of character, quality and quantity.

It is provable by reference to sections Figures 1, 2, 3, and other illustrative drawings in this report, that there exists several of these belts; representing different *geological horizons;* and due to an extra charge of iron given, we know not how, to sediments of different ages. As, on a grand scale iron-bearing rocks occur at various stages of the column of palæozoic rocks from No. I, Potsdam S. S., to No. XII, Coal Measures, —so, within the narrower limits of one subdivision of this column, viz., in the Lower Silurian system, iron bearing rocks occur at various stages, separated by from 500 to 2000 feet. These have already been stated.

FIG. 7.



Summit Cut in Washore with Ore-streaks One foot thick.

The measurements will be given in my Detailed Description of the Ore Banks, and no repetition of them is here necessary.[*] I will only give in tabular form the thickness of the Lower Silurian Limestone formation so far as visible and as measured along Warrior's Mark Run :—

Hudson River Slates..	feet.
Trenton Limestone, &c..	2500
Pennsylvania Furnace and Cale Hollow Ore Banks :	
Interval of Limestones..	700
Huntingdon Furnace Ore Banks :	
Interval of Limestones..	550
Pipe-ore Range near Toll-gate :	
Interval of Limestones..	1500
Pennington, Town, Lovetown Banks :	
Interval of Limestones..	3000
The edge of the Fault stops further measurement downwards :	——
Total visible thickness of Limestones................	7750

---

[*] See No. 31, Huntingdon Furnace Banks.

PRACTICAL VALUE OF THE ORES.

The experience of sixty years has demonstrated the exact values of the brown hematite iron ores of all the Lower Silurian Valleys of Pennsylvania: on the Lehigh; in the Great or Cumberland Valley; in Kishicoquilis Valley; in Morrison's Cove, Canoe and Nittany Valleys.

The general resemblance of ores from all the Banks is striking. The local variations are still more striking. The key to those variations was only got when the true geological theory of structure was studied out. But it is still a perplexing question why red-short, cold-short and neutral ores should lie so near each other. There is scarcely an ore bank in Pennsylvania in which the chemist will not find some infusion of sulphur and phosphorus. But some ores have been so slightly charged with one or other, or both of these elements, that they rank in the first class.

Others are so heavily charged, that they are useless for Bessemer work; take a low rank as anthracite or coke iron ores; and only make good pig-metal when smelted in small quantities, with charcoal and a feeble cold-blast.

This is especially true of those of the lowest geological horison or oldest in age, belonging to rocks of Pitsdam age, rocks which rise upon the flanks of the South Mountain. Fortunately, these ores nowhere reach the surface in Nittany Valley, being buried in the jaws of the Bellefonte Fault. Even the Pennington horison is too high for these ores.

The consequence is, that most of the ores of the district under notice here yield a practically neutral ore and make the best possible iron in cold blast charcoal furnaces, and good iron with the hot blast, and mineral fuel. The appended analyses of Dr. Genth will make this fact evident.

Phosphorus, however, is found in all known Silurian Brown Hematite ores (with some rare exceptions) in quantity enough to prevent the manufacture of steel. But in some cases mixture with other ores will rectify the ore. In other respects the per centage of phosphorus is too small to do hurt. Dr. Genth's analyses will give the figures in this case also.

The reputation of Pennsylvania iron was greatly made at Pennsylvania Furnace. Its quality could not be surpassed. Neither the older Swedish, nor the best English, when English iron was still good, nor the more recent magnetite pig-metal of Lake Champlain and Missouri, have excelled it; and it shared this reputation with furnaces smelting similar ores.

There are parts of the deposit in almost every Bank, which are sandy and lean. These have been hitherto fastidiously rejected by the charcoal coal blast furnaces of the district. Such ores are, however, in demand for our anthracite and coke furnaces, and the ever-increasing market for them will require the mining of the whole. I believe that carefully selected ore from these banks will even furnish iron fit for Bessemer use.

PROBABLE QUANTITY OF ORE.

Estimates of the quantity of Brown Hematite Ores are among the most uncertain of all earthly things. Hence I give special statements of the size of excavation and prisms of ore ground in sight for each of the ore banks, in the chapter of this Report devoted to their local description.

The surface ore wash is of various depths from 1 to 30 feet. The breadth of surface covered is sometimes but a few yards; sometimes several hundred yards. Intervals occur where all traces of surface ore vanish from the belt.

The thickness of the underlying clays varies from a few feet to a hundred and more. Sometimes these clays are loaded with scattered pieces of ore, fine or coarse; at others they do not show a trace of ore. Sometimes the mass of clay is interstratified with layers of rock ore yielding richly.

The rock-ores and pipe-ores, bedded or in packets, under the clays are also excessively irregular, and nothing but actual mining can teach us the quantities concealed.

But any one who reads carefully the following descriptions of the ore banks taken up in succession, must arrive at the conclusion, that the Railway line connecting the ore deposits of Nittany Valley with Western Pennsylvania over Tyrone, and with Eastern Pennsylvania over Lewisburg, will have within the limits of my map, at its command for freight to distant iron works, many millions of tons of prepared ore of the choicest character.

One of the most noticeable features in the iron history of this district (and of others similar) has been denials of the existence of any ore just where the deposits were proved by subsequent diggings to be most copious, and predictions of the speedy exhaustion of ore banks which steadily grew in magnitude and richness as the excavations spread. The history of Pennsylvania Furnace Bank affords a notable instance, and not an isolated one.

There are not less than 100,000 linear yards of ore belt on my map. If the ore were continuous, and only 50 yards wide by 10 deep, we should have 50,000.000 cubic yards of ore ground. If only one-tenth of this were ore, we have 5,000,000 cubic yards of ore. It only needs to look at the number, breadth and depth of the diggings, and their distribution on the map, and to remember that none are noted there but the principal cuts; that large spaces of ore belt have for various reasons never been explored; that in some the ore is seen going down to unknown depths; and that in all the banks water has stopped work—to appreciate the inadequacy of the above calculation.

SPECIAL DESCRIPTIONS.

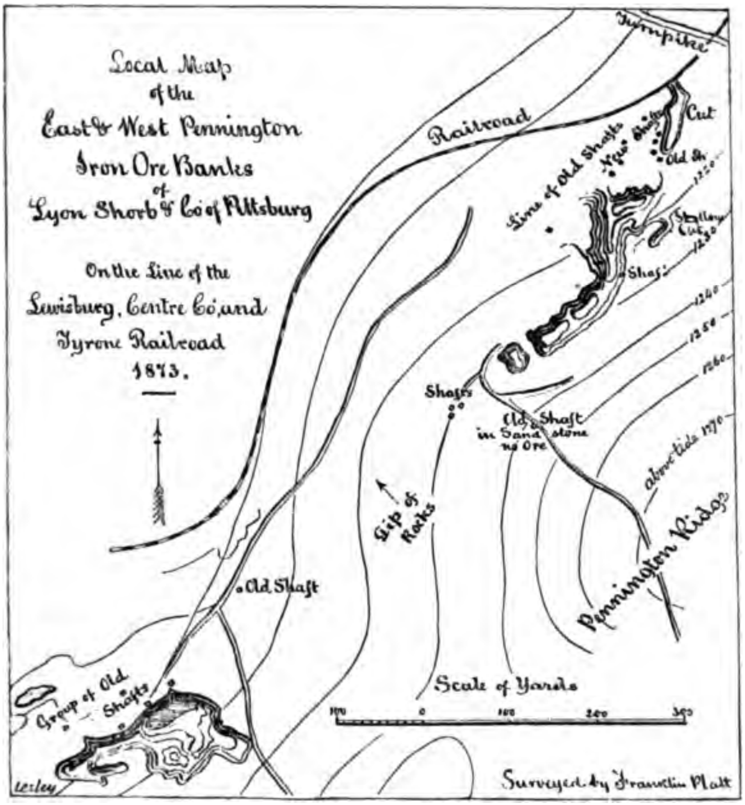
I postpone further economical considerations to introduce here the data upon which what I have written above is founded. The situation and character of the principal mines, are given succinctly, but sufficiently in detail to permit others to form their own opinions.

THE PENNINGTON RANGE.

Cross section A B, fig. 2, shows the ore-bearing limestones at the Pennington Banks dipping ***northwest***, and the hard limestones in the quarries on Logan's Creek dipping also ***northwest*** 23° to 27°, increasing (as we descend the creek) to 90°, and in some places overturned; then, rising at 53°, 54° (S. E. dip), to shoot over the Bald Eagle Mountain.

Cross section A B shows the same ore-bearing limestones at a point on the road to Huntingdon Furnace, a mile and a quarter southeast of the Banks, and on the opposite side of the Ridge, dipping gently ***southeast***, and making a strong outcrop of ore ground.

FIG. 8.



These are our elements of structure. Taken in connection with those of the Little Juniata River section, fig. 1, the geology is evident. There is a low anticlinal arch in the Pennington Ridge, and a sharply plicated little synclinal trough in the Valley of Logan's Creek.

The Pennington ore rocks descend into and beneath Logan's Creek Valley, at first slowly, then steeply, at last vertically, and before reaching the surface again on the other side of the little synclinal, are cut off by the great fault, and are sent down by it to a depth of many thousand feet beneath Bald Eagle Mountain.

On section line C D, fig. 3, no such structure appears; consequently the little Logan's Creek synclinal does not range away northeastward along the foot, but cuts across more northward into the flank of Bald Eagle Mountain.*

As for the Pennington Ridge anticlinal, it loses itself in the hill north of Warrior Mark Village, and in the great fault further on. Obscure dips† of 75° to 80° (N. W.) are seen in calc. sandstone at 500 yards northwest of the village, and 80° (N. W.) in blue limestone, at 450 yards further up Warrior Run; but the universal slant in the country, from there onwards, is southeast; all the outcrops beyond or northeastward of Warrior Mark Village belong to the *southeast* side of Pennington Ridge.‡

The Pennington Bank ore range is therefore a short one, whereas the next ore-range to the south of it runs continuously through Warrior Mark Village and Love Town for ten miles within the limits of our Map.

The Pennington ore rocks are also of an older age than those of many other banks in the Valley, as the sections show. They belong rather to the lower than to the middle division of the Great Limestone Formation. The Pennsylvania, Hostler, and other banks on the Spruce Creek side belong to the middle division. Any constant difference of quality observable between the ores is of course to be ascribed principally to this fact, viz.: that the ore bearing rocks being deposited in two successive ages, and therefore under different conditions, their present dissolubility and receptivity (as regards soluble salts of phosphorus, sulphur, &c.), have bestowed on them peculiarities of individual character.

I consider it possible that the Pennington Range corresponds in age with the Bloomfield ore range, in Morrison's Cove, thirty miles to the south.

The Pennington Range proper consists of a line of outcrops commencing about two miles from the Juniata River, and extending two miles to the railroad, a mile west of Warrior's Mark Village. The northwest face of Pennington Ridge is covered with wash-ore to a variable depth, below which lie sheets, belts, and masses of rock ore, between ribs of still undissolved siliceous limerock. The more argillaceous lime beds have left intercalated sheets of white clay.

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* The Map shows how it swings the mountain a little out of its otherwise straight course, and also how Logan's Creek takes its head just where its synclinal terminates in the mountain slope.

† The cross cleavage of the rocks near the fault makes the direction and strength of these dips doubtful. They look like 30° to 60° (S. E.)

‡ As will be abundantly evident to any one travelling along the road from Warrior Mark to Love Town.

No. 1. The Old or East Pennington Bank, supplied Bald Eagle Furnace with stock for many years. The ore was hauled about four miles over the mountain. It was chiefly got from the large open-cut shown in Local Map, fig. 8; but also from underground gangways following the ore down the dip (N. W.) beneath a clay covering; and from shafts sunk on that side, tunnels or rooms being driven from the bottoms of the shafts irregularly in every direction at the caprice of uneducated miners, who groped always in the dark, without correct geological ideas to guide them, following what they imagined to be the thickest beds and belts of the best ore, and leaving all the rest to stand and be covered up again by the annual tumbling in of their shallow works. Most of these miners were Irish laborers paid by the ton. Water invariably stopped them, and limited the range of workings to a comparatively narrow belt down hill. The great deposits of ore unquestionably lying to the deep (N. W.) are unexplored. Neither maps nor notes of the old works exist.

FIG. 9.

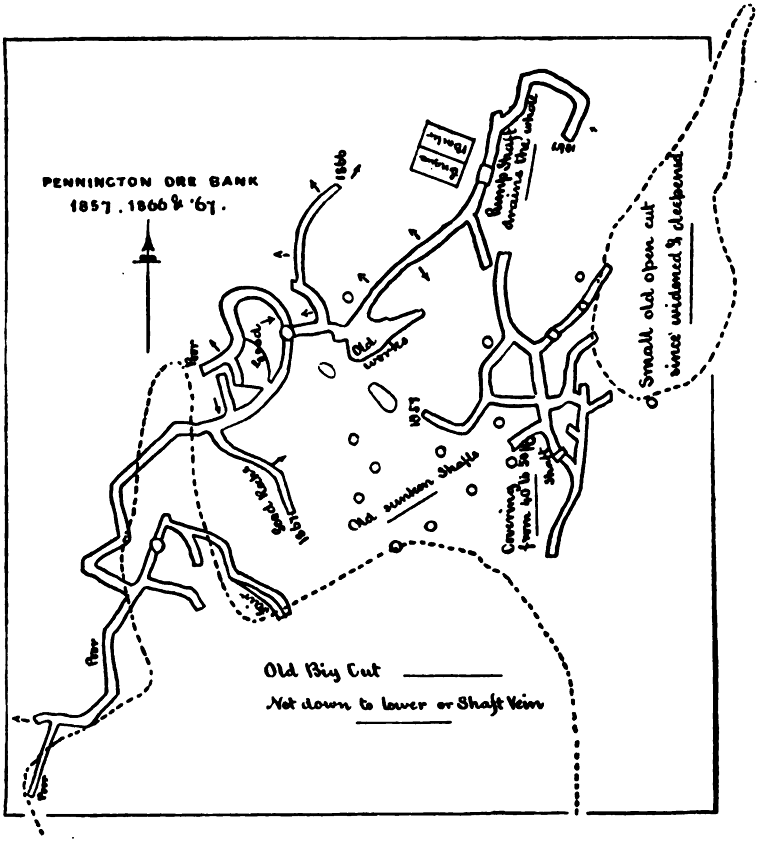


Fig. 9 is a reduced copy of maps made by Mr. H. V. Böcking, mining manager of the Company, to show the position of shafts and direction of tunnels executed under his direction, in a more systematic way.

At the east end of the Old Bank, Mr. Böcking did much sinking on lower ground. One old shaft which had been abandoned at the depth of 30 feet on account of water, he sunk 30 feet deeper to the sandstone floor of the ore, which drained the mine. A cross-cut from this shaft 75 feet long struck the ore descending (N. W.) but where it was nearly level. Galleries were then driven and much ore won in an irregular way. But the heavy spring rains of 1857 filled the works to the top of the shaft. At this time the large deposit at McAtear's (West Pennington) Bank was discovered. In 1865 a new shaft was sunk, in a dry season, a little north of the caved-in works, reaching the bottom of the ore at 45 feet. The shaft was 60 feet deep, and a steam-pump kept it dry by two or three hours work per day. A good vein of ore had been abandoned (on account of water) in a smaller open cut, near the last mentioned shaft, with only 3 or 4 feet of dirt covering to the ore.

That the rich deposits of ore in the old open cut pass down northwestward, in irregular but continuous floors and layers between the clays, was proven by galleries driven by Mr. Böcking west from the pump-shaft, see fig. 9. He describes these galleries as driven in wavy ore, meeting several good bodies of ore. No pillar mining was done, as the sinkings were merely tentative.

In all this no account is made of anything but the better streaks of hard lump or rock ore, which alone a small charcoal furnace is willing to smelt. Great quantities of saleable ore and wash-ore are ignored.

My assistant, Mr. Franklin Platt, obtained the following imformation on the ground while making his map :—

Beginning at the Railroad, the first and smaller pit (now filled with water) 70 yards long, by 15 wide and 5 deep, yielded about 5000 cubic yards of wash-ore, without any solid lump ore. Shaft No. 1, sunk near it, (N. W.) is said to have passed through

1.	Top wash-ore	15 feet.
2.	Rich lump-ore	5 "
3.	Clay with little or no ore	25 "
4.	Good lump-ore	15 "

the bottom not reported. Shaft No. 2, (W.) had lean wash-ore on top ; clay to 40 feet ; good lump-ore thence to bottom at 50 feet.

The main open cut is 230 yards long, with an average width of 35 yards, as shown in fig. 8 ; depth from 5 to 8 yards. Wash-ore, sometimes lean, forms the wall of the pit, from the surface to an apparent depth of 15 feet. A shaft midway of the eastern edge, "struck a layer of ferromanganese ore, 5 feet thick, at a depth of 15 feet."

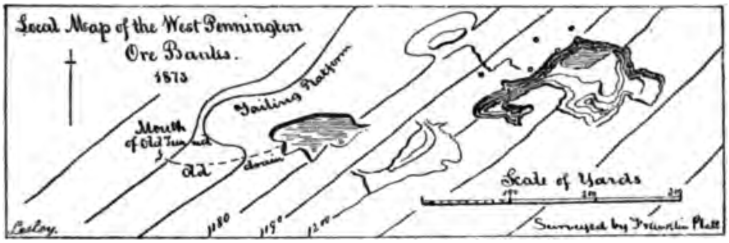
Two-thirds of the distance from the southern to the northern end of the pit, a massive crop of half decomposed calciferous sandrock charged with more or less of ore, juts from the wall, dipping gently northwest.

Some of this rock is genuine iron ore; the rest ferriferous or merely ferruginous sandrock. The excavated ore lay over, under and around this rock, having been freed from other similarly dipping, but more ferriferous and more dissoluble strata.* It is a place where the genesis of our brown hematites may be studied to advantage.

Ore was found in some of the shafts to the south-west of the main open cut.

The whole N. E. and S. W. extent of this uninterrupted expanse of wash ore, from the railway track to the shafts last mentioned, is about 500 yards, and its width, say, 100 yards. A considerable percentage may be too lean to wash.† Estimating the depth of soft and hard ore at 10 yards, we have 500,000 cubic yards. Rejecting one half for leanness, we are safe in supposing 250,000 cubic yards of ore in sight.

FIG. 10.



No. 2. The West Pennington Banks. An interval of half a mile separates this open cut from the East Pennington Banks last described.‡ The railroad, curving across a slight hollow in the side of the ridge, see local map, fig. 3, approaches within two hundred yards of the north

wall of the excavation, see fig. 11, which is 180 yards long, by 40 wide on an average, and shows nothing but wash ore in its banks. Its very irregular depth may be called 10 yards; water standing in the floor.

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* The strike of this rock is *across* the open cut, here very narrow. The ore of the northern end of the cut is therefore above these rocks, and that of the southern portion of the cut belongs below these rocks.

† The "black ore,' which is very rich, is in some places abundant; in other places it becomes very thin.

‡ Mr. Böcking, speaking of this interval, says that after passing a low place at McAtear's, the main body of good ore was discovered in 1857, at the surface, on ground into which old pits had been sunk, the miners having previously condemned the whole locality. The very rich deposit then discovered lay higher up the slope of the ridge, and had thus been entirely missed.

Mr. Platt remarks: "What the original shape of the ore on the face of this ridge was, it is now hard to say; but the two Pennington ore deposits are at present separate and distinct, not necessarily connected in any way. I presume that the original limits embraced them both, and much of the ore lying between them which is now gone."

This agrees with what is seen at the Pennsylvania Ore Banks, to be described hereafter, and it is a strong argument in favor of the wholly outcrop character of these brown hematite deposits. On the other hand, the ore has never been properly followed to the deep, and the distance in that direction to which the dissolution of the ferriferous limestones and the precipitation of peroxide of iron has extended is unknown.

This cut was worked to a depth of 40 feet during seven years, and yielded richly. The first maps are lost. Mr. Böcking's underground works on the north wall, commenced in 1865, are represented by his Local Map, fig. 12, and thus described by him :—

An old whin shaft was pumped out, and pillars robbed. The galleries then caved in, and work stopped. Ore can still be reached from other shafts, two of which are timbered. One body of ore lies between the old cut and the underground works. It is not very rich, but is "good natured," and mixes well with more refractory ores. Another body of good rich ore remains standing to the deep of the works, and has a heavy covering. Another body of very good ore, fifteen feet thick, occupies a trough below the level of the pump-shaft, estimated at say 500 tons. Shaft 5 has ore around it. Shaft 4 is in a fair vein of rock ore. The deposit at shaft 3 is variable, and part of it stands. Old cuts and pits show that the deposit runs on southwestward.

That the ore extends northwards is shown by the late railway cutting 200 yards north of the open cut (see fig. 10), where ten feet of wash ore is seen overlying white and red clays.

Seventy yards southwest of the main open cut is another, 110 yards long, 15 wide, and 8 deep (13,200 cubic yards), nothing now showing but wash-ore in the side walls. It was originally much deeper, slides having partially filled it.

Three hundred yards west of the main open cut is the Old Phillips Bank, 100 × 30 × 6 yards (18,000 cabic yards), full of water. It was once deep, and drained by a tunnel, the mouth of which is shown on the Map (fig. 10), 140 yards from its west end.

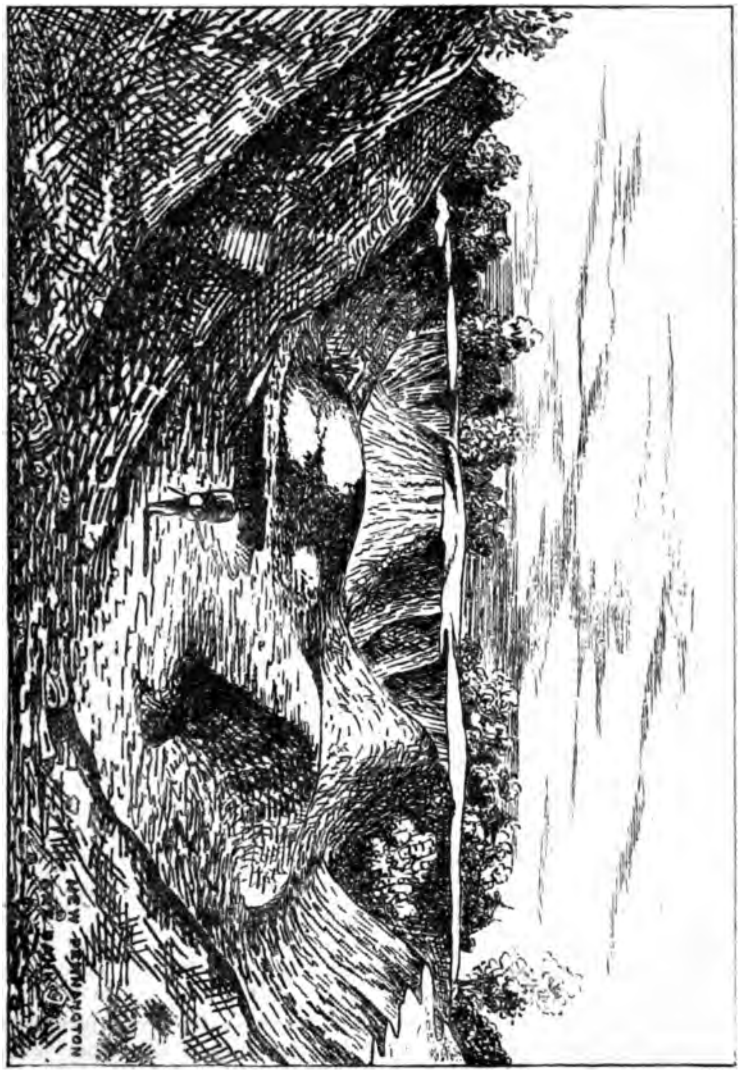
Calling the length of ground occupied by these three open cuts, with their imperfect underground workings, 400 yards, and its breadth 100 yards, and assigning an average depth of ten yards for wash and lump-ore, we get an original mass of 400,000 cubic yards, one-half of which may be considered rich and accessible enough to work to advantage.

But it must be considered that this Pennington Range of deposits shows a much stronger tendency to develop lean layers and sandy masses than the Dry hollow, Red, or Gatesburg Ranges, hereafter to be described. Estimates of workable quantities are, therefore, hazardous. We are here geologically at the bottom of the limestones, and close on the top of the "calciferous sand-rock" formation, which accounts for the tendency to sand-rock and sandy ore exhibited in these banks.

Of the old Phillips bank Mr. Böcking says that it holds purplish easy smelting ore, mixed with clay, and without discernible regular veins. Quantities of wash-ore can be got here; but *dry* screening is impracticable.

This gives the key to the problem of the future. The near presence of the railway makes systematic mining along this range a very different affair from the "ground hogging" of the surface hitherto pursued, un-

FIG. 11.



systematic, wasteful and costly as it of course was. A regular stoping of the deposit on a large scale and the washing of all the ore ground must yield a profitable revenue.

Mr. John W. Harden, an experienced Superintendent of mines, considers the extensive dry tailings, which cover the slope to the north of the cuts, capable of being profitably washed, while being got out of the way of future open cuts.

Traditional accounts of such old ore mines as these are to be credited with due caution and large allowances. But they have their value. It is of great importance, then, that shafts of over a hundred feet have been repeatedly sunk along this range; for they are proofs that experience has justified them; proofs that bodies of ore had been found lying very deep beneath the surface. The open cuts exhibited by the maps (figs. 8 and 10) were once very deep and were stopped by water, *as has been the case with all the ore banks of these valleys.* The miners were always driven from fine beds of rich rock-ore by the influx of water which they had no adequate machinery to keep under. We can easily believe it therefore, when we are told that in the Old Pennington Bank a floor of massive rock-ore from 8 to 16 feet deep underlies 50 feet of a covering, consisting of wash ore and scattered lump ore intercalated between white variegated sandy clays; and that in the West or New Pennington banks the deposit consists of a surface soil with a little ore 5 to 10 feet thick; then wash ore interstratified with layers and masses of white, brown and red tight clays and loose sands from 50 to 80 feet, and a floor of red rock ore underlying all.

My own belief is that when pumping machinery of adequate power comes to be applied to these deposits, and an approved system of mining adopted, many hundred thousand tons of ore will be raised and sent to the eastern furnaces at a living profit.

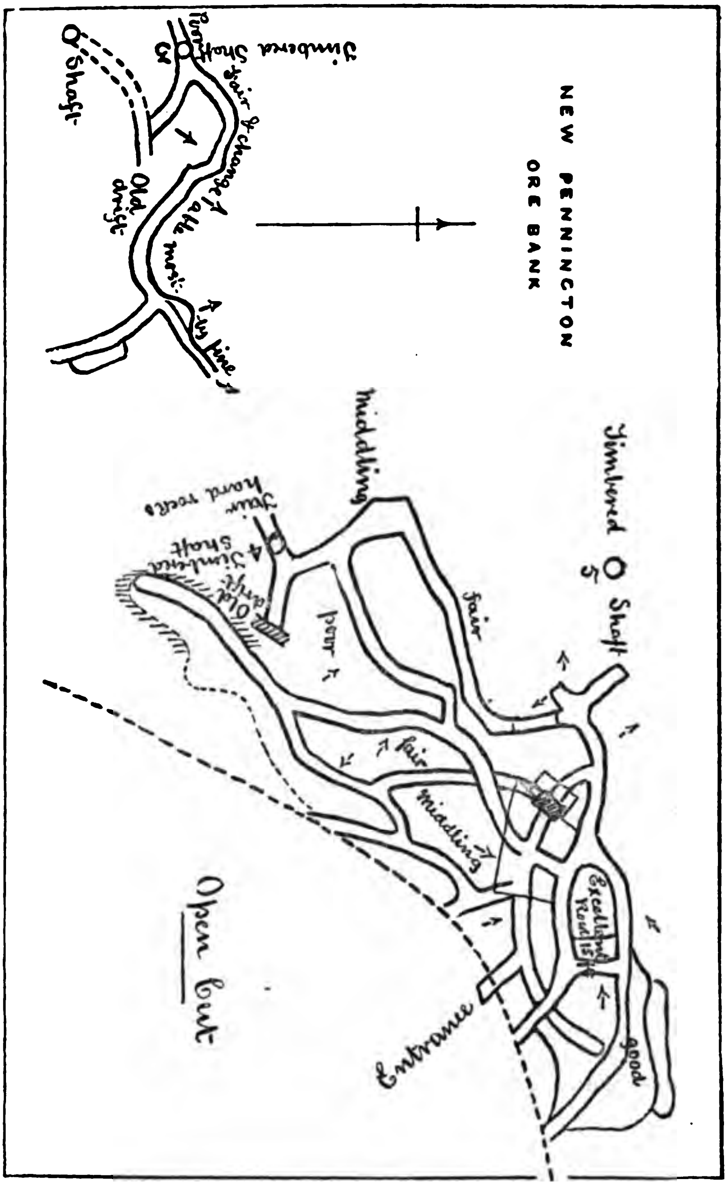
The southwestward extent of the deposits is unknown. But on the southwest of the ravine and hill spur beyond it a pipe-ore and a good deal of "barren ore" mark the continuation of the *Pennington outcrop* through D. Bronstetter's fields, and then across Gyer's farm. It is cut by a gap; and then is again visible crossing Weight's farm, and (on the west land line) reaching to the hill-top. Hence to the Juniata it is hard to trace; but becomes visible again west of the river in Sinking Valley.

No. 3. Beck Bank (marked "nameless" by mistake in the Key List on the large map).

The eastward extent of the Pennington deposit has not been carefully explored; but at the entrance of a R. R. cut, half a mile east of the Old Pennington Bank, Huntingdon furnace mined ore 10 years ago. This Bank shows 40×20×5=4000 cubic yards of excavation, with water in the floor, and wash ore walls, rather lean in quality and quantity, as now visible.

No. 4. New Town Bank, also called **Beck's** (and so designated on the large map), lies 1⅜ mile east of Old Pennington Bank, and was worked for Bald Eagle furnace, and abandoned for want of pumps to

FIG. 12.


NEW PENNINGTON
ORE BANK
Timbered Shaft 3
Poor
fair & change
a little moist
very fine
Old drift
O Shaft
Timbered Shaft 5
middling
fair
fair hard rock
4 Timbered Shaft
Old drift
poor
fair
middling
Excellent Road 15'
good
Entrance
Open Cut

keep down water, "good ore being left standing in the floor." In the woods behind Beck's and Aul's fields, north of it, small shafts were once sunk on fine sized ore. In Beck's Bank wash ore is seen in the walls, showing rather lean. At present there is not much evidence of the presence of a considerable deposit, and no encouragement is felt for looking for it.

The road to Warrior's Mark Village descends to Warrior's Run, past New Town Bank, which seems to be the remains of a surface deposit once covering the flat top of the Pennington Ridge Anticlinal. It is the only mine on this southeast dipping outcrop that has ever been opened west of Warrior's Run. But, that the ore belt extends in that direction, towards the Juniata, is proved by the heavy outcrop of ore ground, shown on the large map and on Cross Section A B, fig. 2, 1¼ miles due south of the Old (east) Pennington Bank.

The vein of ore pursued by those who worked the New Town Bank is described as small and irregular in thickness, and not traced successfully downhill and westward ; but much coarse ore covers the ground in Jer. Berk's fields, on which the Furnace had no right to enter ; slight shaftings showed small veins of ore. Further west also, in Adelberger's fields, some ore was raised ; and outcroppings occur on P. Cooken's farm.

Warrior's Mark and Lovetown Range.

From Warrior's Run, north-eastward we have almost a continuous series of shafts and open cuts for a good many miles ; viz :

Old Town Bank (V) is ½ mile east of Warrior Run ; Romberger's Bank (VI) 1½ miles ; Hannah Bank (VII) 1¾ miles ; Waite's Bank, 2¼ miles ; Lloyd Braunstetter's Bank (IX) 2⅔ miles (with pipe ore outcrops to the south of it) ; Disputed Bank, 4¾ miles, (X) ; Hannah Furnace Bank, 5 miles ; Hannah Furnace and Beck Banks half a mile north of the last two, and less than a mile west of Lovetown ; the pipe ore outcrops half a mile south of Lovetown ; croppings near the sawmill, 2 miles east of Lovetown ; Hannah Furnace Bank and Bryan Bank, 2⅔ miles east of Lovetown, and the Curtin Bank 5 miles east of Lovetown, and 11 miles from Warrior's Run.

The ores of these Banks, when rich, are black or dark colored, much of it of a pitch-like lustre, and often inclining to cold-short in quality. Dr. Genth's analyses in my appendix will give their chemical constitution. When lean, they are of a lighter color, brown, or liver colored ; clay predominating over sand in the deposit, as compared with the Pennington ores proper. Some of them may occupy a slightly higher geological position, being still further removed from the upper layers of the Calciferous Sandrock, and lying, therefore, still more in the body of the Trenton Group* of Limestones.

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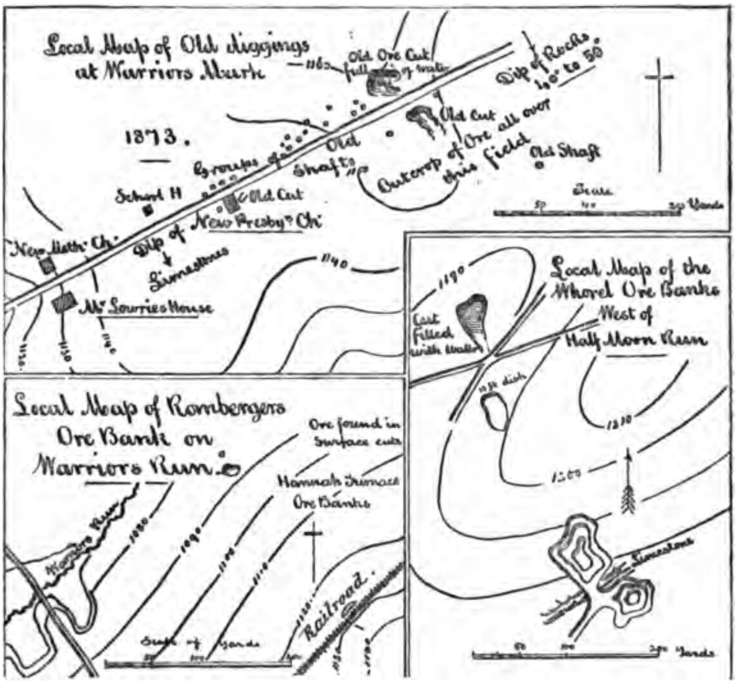
* See sections A B and C D. The Trenton Limestone proper, of the New York Geologists is considered to be the top member of the Trenton group. Our ores are far below it, and in the lower members of the group, viz. the Chazy, Bird's Eye and Black River Limestones.

No. 5. Old Town * Banks, are shown on Local Map, (fig. 13,); two old open cuts, one on each side of the main road, and groups of shafts, principally north of the road. There is a decided ore-show on the surface for 470 yards. Opposite the new church, an old shaft reached a maximum depth of 110 feet, touching "a vein of ore." (Böcking.) Contradictory accounts are now given of this work. Some say, that the quantity of ore was enormous, timbers 30 feet† long being used to support the chambers, the ore dipping steeply N. W.; and that massive ore stands in the sides and at the bottom of the deserted mine. Others say, that the ore mass, 25 feet thick, descended vertically with undiminished size when the shaft was abandoned. It is may be a deposit in one of the ancient caverns or cross fissures of the Limestone Formation.

FIGS. 13, 14. FIG. 17.



Shafts sunk to depths of 30 and 50 feet sometimes went through clays without ore. Mr. Bocking sunk one 80 feet deep to find a mass of ore said to exist between three old shafts, but found nothing. The surface wash ore is sometimes only 2 or 3 feet deep; in other places 20 feet. No estimate of quantity is possible with such information. The visible area measures about 67,500 square yards.*

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* Called Town Bank, on the Local Map.

† The rocks of the neighborhood dip 25° to 35° S. E.

A little pipe ore has been found higher up the hill north of the road.

Regular and progressive stoping from the south-west, along the belt, may produce large results in the future. But the oreless clay of great thickness intervening between the surface wash and the deep hard ore will make mining expensive.

No. 6. Rumbarger's Bank, (Local Map, fig. 14,) is an open cut in the south bank of the east branch of Warrior's Run, the surface of the ground only rising 6 feet above the bed of the stream.

A cross-road separates the excavation into two; that on the southwest, 40 × 40 × 10 yards deep; that on the northeast, 30 × 30 × 10 yards deep; 25,000 cubic yards in all. These pits reached a depth of 40 feet, wholly in wash-ores and clays, without striking solid limestone. The rock ore left in the bottom when the work was drowned out, is *reported* to be less abundant than that found above it. But as the ore streaks "dipped fast to the southeast," and the limestone out-crops of the neighborhood dip from 22° to 34° in that same direction, (see Large Map,) good mining will probably yield well. Plenty of good ore has been won here, and nothing but the lack of pumping machinery stopped the winning. Thos. Funk worked the Banks at one time for the Milesburg Company.

The ore belt passes on eastward under Is. Buck's (now Smith's) lands, where Messrs. Green of Barree raised ore, but took no sufficient means for establishing a mine.

Thence it enters and underlies S. Hanna's farm, with its numerous ponds and sink holes, full of promise for the future.

A mine for Bellefonte Iron Works has just been opened (August, 1873,) at a point 300 yards northeast of Rumbarger's Banks, (see Local Map, fig 14,) where a very heavy outcrop exists. Every cubic yard is washed profitably. The cut is yet only 4 or 5 feet deep.

As a heavy surface show extends 150 yards beyond Hannah Bank, we have here an area of 450 × 50 = 2250 yards of wash ore of undetermined depth; besides the rock ore undoubtedly existing further down.

Mining and washing will here be cheap, and the railway runs along the hillside at a distance of 200 yards, and at an elevation of 35 feet, (fig. 14).

Further on, the surface show is slight, or wholly wanting,† until we reach the next excavation.

No. 8. Waite Banks, shown in Local Map, fig. 15, consist of two pits, 100 × 20 × 7, and 90 × 20 × 7 = 26,000 cubic yards, in size, more than 20 feet depth of good-looking wash ore being seen in the sides, and much lump-ore having been won by still deeper shafts in the intervening ground. The entire ore prism must therefore exceed 150,000 cubic yards. The Railroad is a mile distant.

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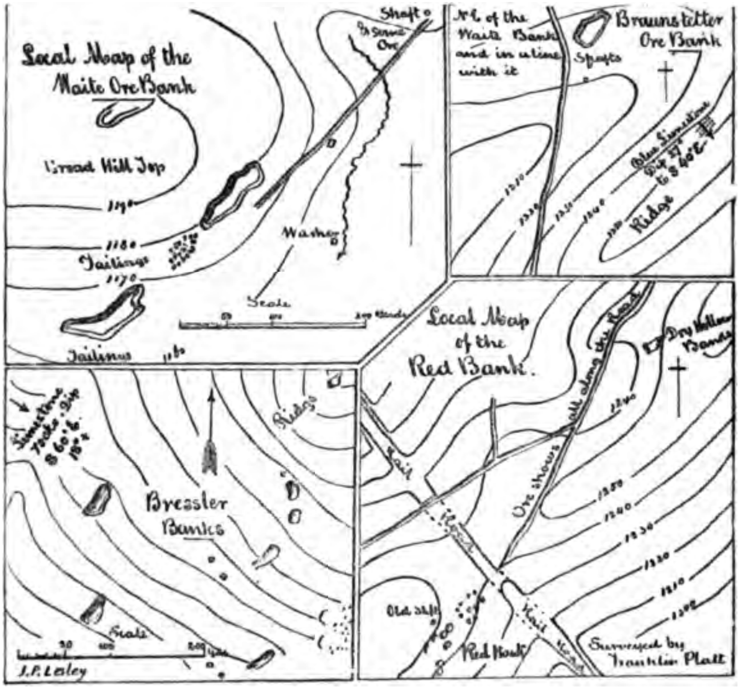
* Ore is found in the soil of Petershoff's farm on the south of the Town Banks. There is an old digging on the Hyskel (B. M. Thompson) farm; and further west outcroppings on Thom. Gano's, whose trial pit on a small vein near his orchard was stopped by water; lively outcroppings show in several fields up the slope of Dry Hollow ridge.

† A shallow pit ¼ mile from Hannah Bank yielded some ore. The Waite Bank is 400 yards northeast of this shaft.

No. 9. Braunstetter's, or the McGlathery Bank, is situated about 1200 yards beyond (N. E. of) the Waite Banks, and the interval shows little on the surface; yielded only some lean ore to one or two trial

FIGS. 15, 16. FIGS. 18, 19.



pits. This Bank, (see Local Map, fig. 18,) is only 30 × 20 × 10 = 6000 cubic yards large. It is said to have been worked to a depth of 40 or 50 feet, but is now fallen in and full of water, and no one seems to know much about it. Overlying Limestones crop out 150 yards southeast of it, dipping 27° S. 43° E.

Further on is the old Disputed Bank, on the high divide, between Warrior and Half Moon waters. Here are several small shallow open-cuts and shafts in surface ore; but no deep mining has ever been attempted. The ore seems to dip south, and is sandy. The crop traced westward, becomes good and plenty on Jos. Bronstetter's farm, who has never made judicious trials of the deposit, and through the hollow leading to Patton's (now Waite's) and the Lloyd Bank, above mentioned.

No. 10. The Lovetown Banks, consist of numerous open-cuts and shafts from which large quantities of ore have been extracted and extensive preparations are in progress for regular mining of this important part of the ore field. The principal outcrop occupies a vale watered by a small branch of Half-moon. The old shafts of Abram Love were stopped by the influx of water. Pipe ore is visible near Love's barn. Half a mile west is an old "exhausted" Hannah Furnace Bank. On the north slope of the ridge west of Love's, ponds and sinkholes abound. Hannah Furnace had a Bank in David Berk's fields, and abandoned a good deposit of ore in its floor, merely on account of water. Surrounding shafts were also sunk, but no pumps were ever planted. A few hundred yards west of the open-cut, some of these shafts went through a pretty good "top vein" into a regular deposit 20 feet beneath the surface. Southwest of this other shafts were sunk for the Milesburg Company, in Abed. Stevens' fields, in good rich, sandy, black ore, close under the sod, the poorer clay ores lying down on the limestone foot of the hill. South of this, John Stine gathered much loose heavy ore from his fields, and hauled it to Bald Eagle Furnace, many years ago; but no sinkings were done. The outcrop is noticeable in Jos. Bronstetter's lane (leading to Wrye Bank) and in his fields on Cronister's line.

The Lovetown Banks are shown on Local Map, fig. 20, occupying two vales, descending eastward to the Half Moon Run, at the mill-dam.

A rib of solid blue limestone strata, dipping S. 30° E. > 56° to 57°, forms a low hill, up the south slope of which the wash-ore rides on to the flat summit. Natural ponds occupy, at points, the beds of the two vales.

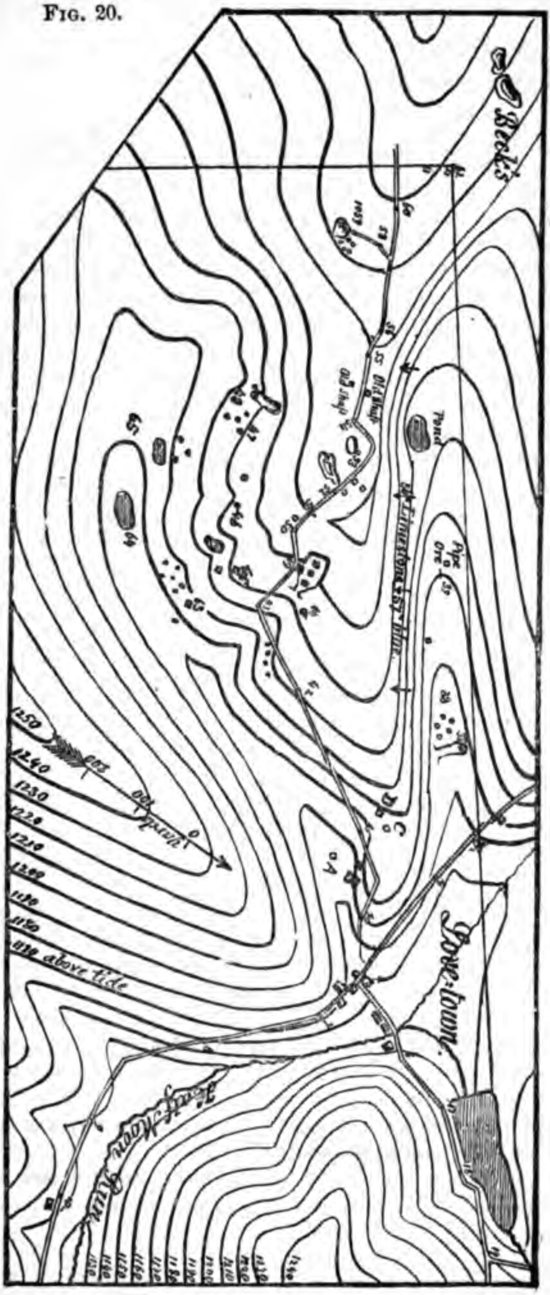
The north line of the Love property commences near the Beck Banks, and runs down the northern vale to the corner of the mill-dam. The ore has been open-cut at Station 37, 165 yards west of where this line crosses the road. This once deeper old cut is now only ten feet deep, showing in its walls liver-colored, somewhat lean, wash-ore. West of it is a series of shafts for 450 yards, formerly sunk 60 or 80 feet (without timbering) until water was reached, and after a little side-drifting, abandoned. Hannah Funace ran for some time entirely on the ore got in this primitive fashion from these holes. In one of them (St. 39) pipe-ore was found. Nothing more is now known of them. They are evidently on a continuation of the Beck Bank deposit, the result of decomposition of ore-bearing strata *underlying* the rib of blue limestone at Station 56.

The rest of the ore on the property belongs to the series of rocks *above* the blue limestone, and to the southern vale.

The first shafts are sunk near Love's house. Shaft A struck ore at 35 feet; B, pipe-ore at 35 feet. Ore has recently been found southeast of A, on the foot of the opposite hill.

From Station 44 there extends east and southeast down across the

FIG. 20.


Beck's
Old Shaft
Old Shaft
Pond
Limestone
Pipe Ore
A
C
D
Forge-town
Half-Moon Run
1250
1240
1230
1220
1210
1200
1190
1180
1170 above tide

bottom of the vale, and west and southwest along the hill-slopes and hill-top, a universal surface deposit of wash-ore. In this area are numerous old shafts, pits, and open-cuts, and some new shafts sunk this summer and fall. The old works were always abandoned on striking water at various depths down to 80 feet, and are now filled up, and no records preserved. Much ore was certainly mined from them.

The new shafts show that from 8 to 15 feet of wash-ore in clay underlies the surface at the depth of a few feet, and that under the yellow and white clays there lie separate deposits of ore-lumps, the geographical intervals being barren. There seems to be no regularity of the ore layers.

The old shaft at Station 48 is said to have passed through twelve feet of surface wash, then (ore-bearing?) clays to a depth of 80 feet, into lump-ore, which was mined for several feet, and left in the bottom when water stopped the works. The new shaft, only ten yards southwest of the old shaft, is down 80 feet, and found no ore in the clays. The ore got seems rich and rounded, as if water-worn.

It may be safe to give twelve feet of wash-ore to the whole area, under which are hard ores, yielding sometimes richly and sometimes nothing.

The surface ore extends 850 yards along the top of the hill. Most of the pits were shallow, but one at Station 59 is said to have been 115 feet deep through wash- and lump-ore, with ore left in the bottom.

The general appearance of the deposit is the same as at the Dry Hollow and Wrye Banks.* No regularly interstratified ore is noticeable. No estimate of quantity can be relied on. Taking only the area of heavy surface show, and calling it 850 × 300 yards, and the depth twelve feet, we have 1,020,000 cubic yards of seemingly good wash stuff, which, at 3 cubic yards to the ton, gives 340,000 tons.

To this must be added the very uncertain quantities here and there scattered through the under clays. As these have been sometimes locally considerable, it is possible that one or two or even three hundred thousand may thus be obtained. As the principal part of the lump-ore is evidently at the bottom of the clays, no knowledge of the quantity can be got until systematic mining reveals the truth.

Wash-ore ground here must be considered as the main reliance for the present. Washing here is easy; abundance of water is struck at 50 or 60 feet, and there is plenty of room for settling dams. The railroad line, adopted for a branch to the main railroad, rises one mile on a 92 feet gradient, and descends one mile on a 46 feet gradient.

The ore has a much more extensive range than that above described, for Mr. Fisher has opened three small pits on ore just beyond the northeastern property line; and the Beck Banks show that it passes southwestward into the adjoining properties in that direction also.

An analysis of Lovetown ore, from the large pit at Station 49, fig. 20, made at my instance by Mr. Persifor Frazer, Jr., Professor of Chemistry in the University of Pennsylvania, shows a percentage of phosphorus low enough to bring this ore within the limits of safe use in the manufacture of iron for the Bessemer process. The specific gravity of the specimens was 3 52. The calculated percentage of metallic iron was 45.36 ; alumina 16.53 ; silica 6.63 ; lime 0.58 ; sulphur 0.04 ; and phosphoric acid 0.05.

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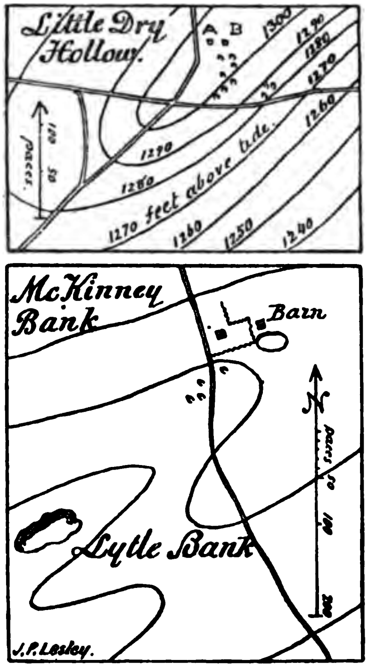
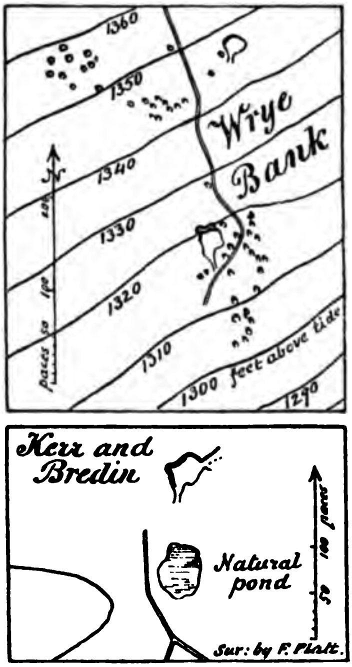
* Hereafter to be described.

Between Lovetown and Stormstown (a distance of 3¼ miles) no ore is visible near Bald Eagle mountain, although considerable quantities of ore lie in the fields just northeast of Lovetown ; but on a line parallel with the mountain, and about a mile from its base, in a hollow leading from one branch to the other of Half Moon Run, a very fine outcrop range of tolerably big pieces of ore, closely covering the surface, runs past the sawmill. It leads directly to the two Bryan Banks, and is therefore important.

Figs. 21, 22.



Figs. 23, 24.



No. 11. Lytle's Bank ; No. 12. McKinney's Bank. These are the old Bryan Banks, 2½ miles N. E. of Lovetown, as shown at the eastern limit of the Large Map, and in Local Map, fig. 22.

The Lytle Bank was worked a long time ago for Hannah Furnace, and measures about 70 × 20 × 10 = 14,000 cubic yards. Very little lump-ore is now visible, the walls showing about 25 feet thickness of wash-or

McKinney's Bank, worked for Pennsylvania Furnace, is much smaller, say $25 \times 20 \times 10 = 5,000$ cubic yards, and exhibits the same aspect.

Shafts sunk between the two excavations on both sides of the road, leading south from Stormstown to Gatesburg and Pennsylvania Furnace, always struck good ore, dipping to the southeast; as do the limestone outcrops of the neighborhood. We have here a prism of ore deposit at least $350 \times 100 \times 10 = 350,000$ cubic yards in size; probably, after all due allowances, quite that many tons of ore.

The **Curtin Bank**, a long, narrow open-cut on a prolongation of this outcrop, beyond the limits of the map, $2\frac{1}{4}$ miles N. E. of the McKinney, and the **Lamborne** Bank, $1\frac{3}{4}$ miles further in the same direction, have yielded cold short ores, similar in appearance to the Pennington. These and other works of less importance show the persistent straightness of the outcrop of the ore-carrying strata, parallel with the Bald Eagle Mountain, at the foot of which flows the east or main branch of Half Moon Run, with a limestone ridge* between the Valley of the Run and the ore. The Valley of the Run marks, of course, the line of the Great Bellefonte Fault.

At McKinney Bank we are three miles from the railway, where it strikes and begins to descend Half Moon Run. The Lovetown Banks require a railway two miles long, descending the west branch of Half Moon, with a grade of 40 feet to the mile, or else a railway across the ridge $1\frac{3}{4}$ miles long, with gradients 90 feet to the mile, as described. The line of the road was originally located to Lovetown, and thence down Half Moon; but it was considered more desirable to carry it across the Dry Hollow, among the ore-banks to be hereafter mentioned.

Before returning to these banks and the neighborhood of the railway, I will describe a group of banks lying south of the Lytle and McKinney Banks, at the east edge of the map, and on outcrops somewhat higher in the Lower Silurian Series.

Dry Hollow Range.

No. 13. Hannah Furnace Bank No. 2. Two hundred yards east of the Gatesburg road is a hole $40 \times 20 \times 10 = 8,000$ cubic yards in size, excavated on the broad, flat top of a ridge, as shown in Local Map, fig. 25. It was long ago abandoned. The ore seems good and abundant, 15 to 20 feet of wash-ore showing in the side walls, and coming close to the surface. All the down-slid stuff may be washed. Massive sandy limestones, 180 yards N. W. of it, dip S. 30° E. > 28; 150 yards further N. W., massive white sandrocks dip the same.

No. 14, Bull Banks, half a mile east of the last, and in line with it, consist of two excavations on the south brow of the ridge; see A and B, local map, fig. 27. Much sandy ore was formerly taken out before these banks were abandoned, 20 years ago. $A = 60 \times 50 \times 10 = 30,000$, and

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* This ridge, by an oversight, is not represented on the Map, no surveying having been done north of the McKinney Banks.

B=80×40×10=32,000 cubic yards. A shows wash ore in the side, which is 30 feet high above the water in the bottom. B shows about 30 feet of reddish wash ore, with very little lump ore, from the water to the surface of the hill. A neighbor who had worked in the pits, reports that several feet of deep brown richer ore was found lying everywhere in both banks beneath the mass of reddish leaner ore. All this awaits the time of improved mining with pumps and washers.

FIG. 25.

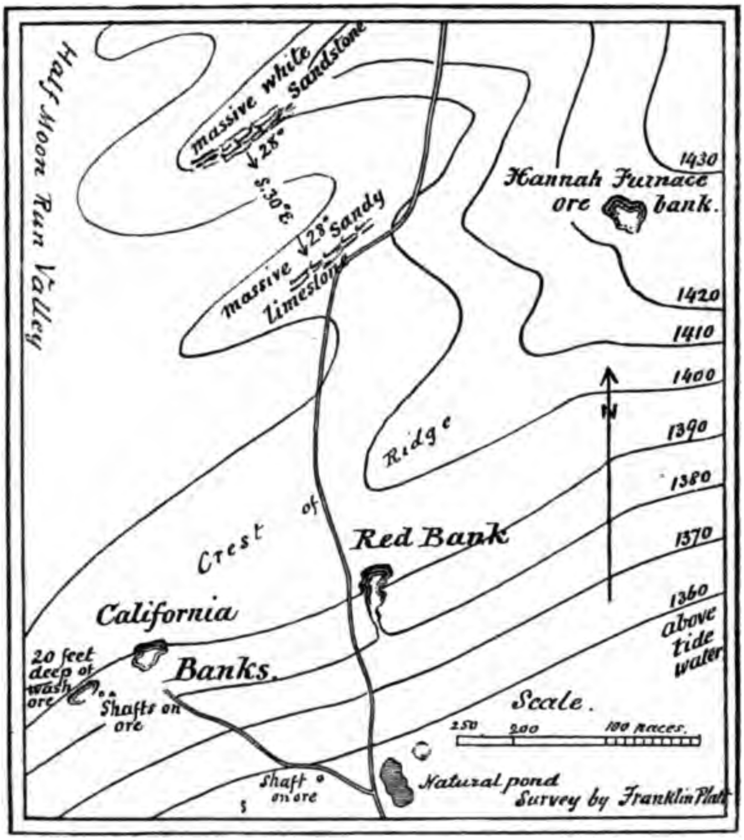

Fig. 27 shows other old workings in the same deposit from 600 to 800 yards to the south-west of A and B. From two of these there have been taken about 15,000 cubic yards of wash-ore, which still exhibits itself 20 feet deep in the walls; the one furthest to the north-west in fig. 27, has been deep, say 40 feet, but now, like all the larger cuts, has standing water and mud in its bottom. Numerous shafts, all yielding ore, give us data for calculating an ore prism in sight of, say 150×200×10?=300,000 cubic yards.

No. 15, Pond Bank, No. 1, worked for Pennsylvania Furnace, lies in the hollow at the foot of the ridge, ¾ mile south of the Bull Bank, see local map, fig. 20. Its honeycombed, rather light, easy smelting ore, (mixing well with the more sandy ores of the Bull Bank Hill,) dips also south-east, and therefore belongs to a limestone out-crop still higher in the series, which is sufficient to account for its different quality. A great deal has been removed from this Bank; but much still remains to be won, and water to wash it is abundant. This is included in the prism of ore calculated last above.

No. 16, Red Bank, (Floyd's Old Bank) at the road side, half a mile south-west of the Pond Bank, (see Local Map, fig. 25,) is a cut in the same out-crop. The amount of ore is therefore very great; for the continuity of the deposits has been fully proven. The red rock-ore (35 or 40 per cent.) descends in a solid stratum from 8 to 10 feet thick, at a dip of about 25° to the S. E. Over this lies a stratum of white clay, 3 feet thick. Over this black ore in solid masses and great lumps scattered thickly or thinly through several yards of wash ore, to the surface. Some of these lumps are 2 feet long by 1½ feet thick.

This Old Gatesburg Bank, as it is sometimes called, was worked 40 years ago, and has been re-opened now to show its character.

The red ore was too siliceous, and hard to work in the small cold blast charcoal furnaces of the region; but it will be eagerly sought by modern hot blast coke or anthracite furnaces.

The black ore masses were selected for charcoal cold blast use, having 50 to 55 per cent. of iron and being fusible ore.

It is impossible to say how deep these strata descend on their 25° dip in a peroxide condition. But allowing only 100 feet, we have in a mile of outcrop 150,000 cubic yards of red rock ore; and as the wash ore ground holding the black lump ore descends with it, and spreads over a belt of surface more than 100 yards wide, there must a be half million cubic yards of it at the lowest computation.*

The old cuts at the elbow of the road west of the two ponds in fig. 27, have had about 8000 cubic yards excavated and are now filled with water to within 10 feet of the urface, showing that much wash ore without lumps. The two larger cuts 150 yards north-west of them, measure about

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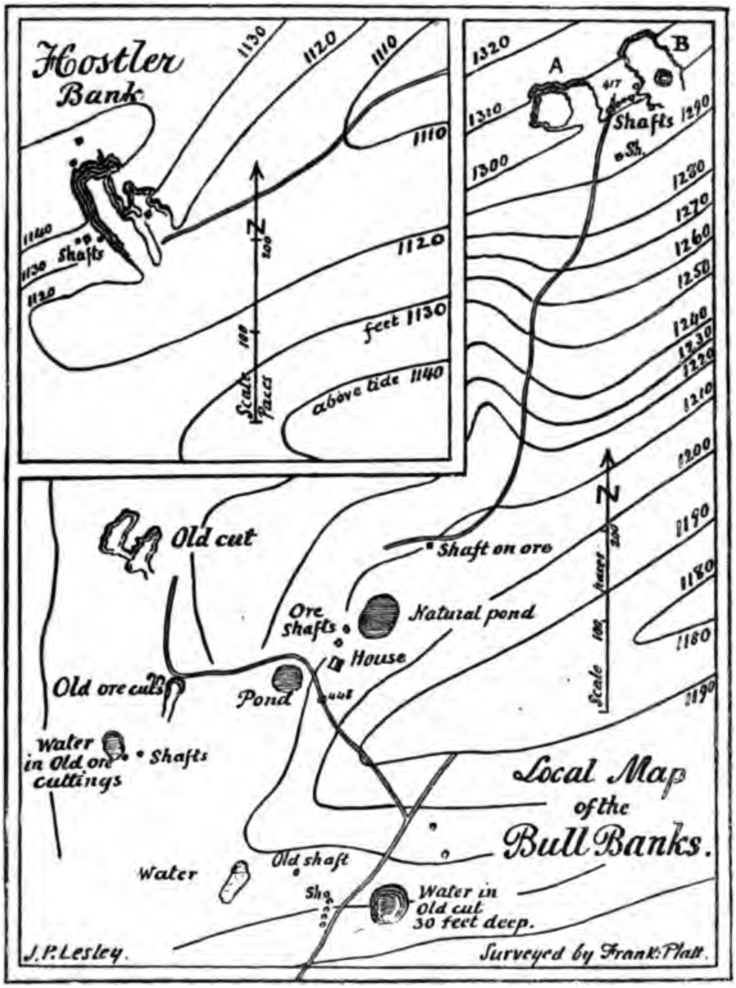
* I have described above only what I saw. Mr. Platt was informed that under 12 feet of clay holding black lump ore, lay 4 feet of white clay without ore, under which lay 14 feet of red rock ore in red clay, and ore was still underfoot. I give this report for what it is worth.

Mr. Böcking speaks of red rock ore only 6 feet thick, "and another fair layer in the clays above, all workable; red ore not very rich; silicious, but with visible sand; rich black ore in the top vein, [the word he always uses for a stratum of ore]; on the whole, proper for coke furnace use; mining requiring pumps; deep workings at hand; an important locality."

15,000 cubic yards, with 21 to 25 feet of wash and lump ore in the walls; abandoned 20 years ago.

No. 17. California Bank, 200 yards west of the Red Bank, and on the same slope and outcrop (see Local Map, fig. 25, (received its name from the richness of its ore, before it was abandoned 20 or 25 years ago, on account of its distance from Pennsylvania furnace, the abundance of water and lack of pumping apparatus, the refractory quality of its mineral in the cold blast charcoal stack, and especially the abundance of

FIG. 26. FIG. 27.



good ore at the Furnace itself. Pits of standing water show 20 feet of wash ore in their walls.

This completes my sketch of this "dry hollow" outcrop east of Half Moon Run. It is a dry hollow because the whole limestone underground is cavernous, and water springs up abundantly in every excavation, but does not flow over the surface. This is a prime factor in the problem of he genesis of these ores, and must be taken into consideration in all speculations respecting the depths to which the brown hematite ores descend in a minable form.

The outcrop belt of surface wash ore and regular rock ores in which the Hannah Furnace, Bull, Pond, Red and California Banks are excavated, passes on north-eastward into the untried wilderness of the Barrens, where we find upon it the Floyd Bank, an open cut on highland; ore very sandy for charcoal furnace use, but good and abundant for hot blast coke or anthracite; and good charcoal ore could be selected from it still.

No. 18. Reider's Bank, half mile east of Gatesburg, is a small surface opening of 30×20×5 — 3000 cubic yards extent. On trial at Centre and Hannah Furnaces it was refused. The surface of the broad low hill north of the village is a sheet of wash ore. The roads north to Stormstown and west to Warrior Mark expose ore ground at the surface, on the slopes of the dry hollow in which the village stands, and to the north and south of the village. The old opening on the roadside 250 yards south of the village, is entirely filled up. Considerable quantities of very rich lump ore were taken out here many years ago, mostly from underground galleries. Much ore ground occupies the surface for more than 100 yards north-eastward. Limestone crops out 300 yards west of it dipping S. 30° E. > 20°, and 300 yards north of it dipping S. 30°E >18°.*

No. 19, Whorrel Bank, (see Local Map, fig. 17,) is a continuation south-west across Half Moon Run of the Gatesburg outcrop, which is here nearly 500 yards broad. The open cut on the north side of the Gatesburg road is about 40×13×5 — 2600 cubic yards; that on the south side 30×20×3 — 1800 cubic yards. Both have standing water in the bottom, and wash ore in the walls, while very heavy outcrops appear along the road, as well as along the cross-road leading up the ridge north to Lovetown, beyond which an old shaft has struck the underlying sand rocks.

The double excavation in fig. 10, 110×40×7 — 30,800 cubic yards large, is separated by a stratum of limestone dipping S. 30°E., >26°, (one exposure looking like >50°,) the ore underlying, overlying and surrounding one end of it. The wash ore in the sidewalls does not look rich. It is reported that these holes were dry 40 feet deep and yielded good ore.

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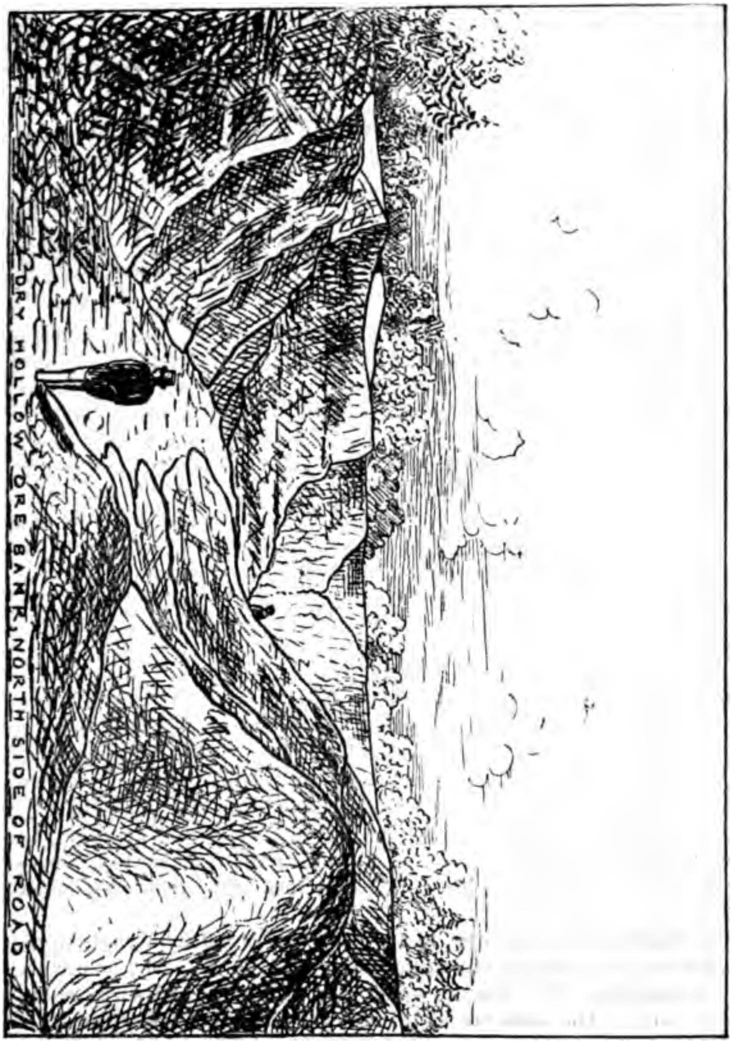
* The horizon of this and the Whorrel bank is still higher in the series than the last, as Section C D (fig. 3) will make evident.

The length of the surface show *i. e.*, S. W.—N. E. is only 50 yards, to be terminated by the erosion of Half Moon Creek Valley. The railroad is only 400 yards distant.

FIG. 28.


DRY HOLLOW ORE BANK, NORTH SIDE OF ROAD

No. 20. Pond Bank, No. 2. is a small excavation 35×10×5 = 1750 cubic yards, at the head of the hollow, or rather on the divide where the south branch of the long Dry Hollow proper begins to descend towards

Warrior's Run ; and along side of one of the summit cuts of the railroad. Good wash and lump ore show in the walls. No sandy ore is seen. The R. R.cut shows 10 feet of wash ore for a length of 100 yards. Altogether we have here say, 40,000 cubic yards of ore in sight.

No. 21. Wrye Bank. The local map, fig. 23, shows this extensive group of shafts commencing 450 yards northwest of the railway track, at an elevation of 40 feet above it, and continuing along the road up the slope to an elevation of 100 feet above the R. R., a distance of 400 yards. Over most of this surface the show amounts to little, proving how little we can rely on the surface indications as negative testimony. For, these works were extensively driven from 1852 to 1857, and yielded some very rich ore, while the surface showed only poor sandy ore.

There is one open cut, 25×20×10=5,000 cubic yards large, showing wash ore in the walls from top to bottom, none of it rich, decidedly sandy, holding ironstained calc. sandstone masses, as at the east Pennington Banks. Very good open ore, bluish, and heavily charged with manganese occupied the west end of this open cut (Bocking). An old miner reports, that in the shafts they went through 26 feet of pretty worthless loose stuff and then worked 18 feet of good lump ore, without getting through ; that the shafts up the hill were dry ; those lower down quickly filled with water, and were therefore abandoned, one after the other, before they could get out more than 10 or 12 feet of lump ore. What the charcoal furnace miners called worthless is now valuable for hot blast, especially anthracite furnaces, and the whole of this great deposit will be washed and sold. The breadth of the belt of shafted ground is about 100 yards, but must be considered as indefinitely greater along the strike.

I am informed that in these old diggings the body of ore sank to 50 feet beneath the surface and thinned away, but came in thick again lower down, and approached the surface. Two good pillars are known to be left standing in the old works, under a top covering of sand, one at the lower end, the other at the upper end of the works. In the last, solid rich rock ore lies 45 feet beneath the surface. All the shafts are now caved in. The ore layers were traced for several hundred yards eastward by trial shafts.

The appearance of this ore differs from that of the Pond Bank No. 2 so much that we should suspect them to belong to a different geological horizon. This suspicion is almost confirmed by the general southeast dip of the outcropping rocks here and there exposed at the surface. This important structural question is clearly expressed by my Section C D (fig. 3), which passes through these banks. It is quite certain that the rocks which on dissolution delivered these ores, are the mother rocks also of the Kerr and Bredin, Hostler and Pennsylvania Furnace ores to be described hereafter. The great breadth of the Dry Hollow Outcrop belt corresponds with that of the localities just named, and I think it pretty evident that we have here two horizons of Lower Silurian ore-bearing limestones close together.

The old **Sandy Bank** is a group of small shallow pits, in very sandy surface ore, but rich and good when washed, on the hill slope a few hundred yards northeast of the Wrye Bank, showing the continuation of the outcrop in the direction of Half Moon Run.

In the other direction, the outcrop has been exploited at the old **Pond Bank** of Bald Eagle Furnace, 500 yards southwest of Wrye Bank, and nearly in the bottom of the vale, which deepens rapidly.[*] It lies close to the foot of Hickory ridge; ore light but good, not sandy, and easy to smelt. A pond, dry in dry seasons, covers some of the old diggings. Much surface ore covers the neighborhood, and it will hereafter be an important mining ground, with heavy clay cover to the ore, requiring hard pumping.

Top ore of large size abounds around a sink-hole in Isaac Gano's fields, on the north slope of Hickory Ridge, a mile S. W. of the pond. The pieces seemed rolled from an outcrop of good ore seen half-way up the hill, in the Huntingdon Furnace woods.

At **Simpson's Bank** (¾ mile further west) the wash-ore is good and easy to smelt. Whereas at **Andrew's Bank**, adjoining, (the Warrior's Mark and Pennsylvania Furnace Road separating them,) sandy ore only has been taken from the open cuts, but no shafting done.

Jos. Krider's fields are covered with very rich scattered pieces of ore, some lumps weighing 400 pounds. Attempts to find a bed at a little gap near by, have failed thus far. The shafts were tried in thick woods; others were too low on the hill slope, and encountered only wash ore. There is undoubtedly a heavy rock-ore deposit somewhere. Similar shows are again seen half a mile further on (west) opposite the old wash-machine, and Huntingdon Furnace has picked off the surface much of this loose block-ore. A small layer was found in two or three shafts, but never followed up to see what would come of it.

No. 22. Dixon's Banks are only a few small holes, fallen shut, with a slight sandy ore surface show, 100 yards west of the road, where it crosses the head of the middle branch of the Dry Hollow. Here "a small irregular vein yielded good ore a little west of it, on a detached knoll, a thicker vein of poorer, flinty ore was found, at the edge of a pond, and was thought not to pay for pumping, to get for charcoal furnace use.[†]

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[*] This and the following named Banks are not exhibited on the Large Map, because not accurately located. Their descriptions I got from Mr. Böcking's notes.

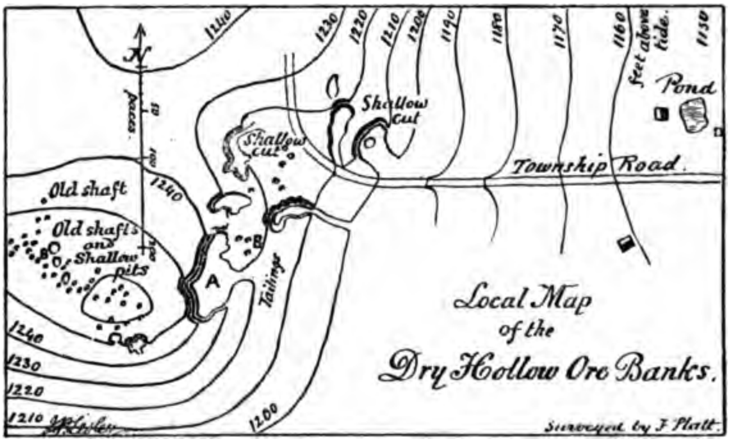
[†] Mr. Böcking thinks he remembers that this vein had a decided northern pitch, and distinguishes it thus from all the other veins of this range. This must be either a mistake or a mere local accident. Mr. Platt's field notes also mark a doubtful N. 30° W. > 34° dip of the limestones in the through-cut 240 yards northwest of Railroad section stake 81–80. But 100 yards N. E. of the same stake, soft rotten limestone strata dip S. 30° E. > 20°. Other Railroad exposures show that the S. E. dip dominates the structure. Thus at Railroad station 4145, is a thorough-cut in blue limestone, dipping S. 30° E. > 34° with regular cleavage planes N. 60° W. > 70°; at 4151, a good exposure of limestone gives S. 30° E. > 26°. In Railroad cut at 4164, sandy and blue limestones the layers seem to dip S. 60° E. > 31°; in the cut 180 yards S.W. of Railroad 4180 hard, sandy limestones dip S. 45° to 50° E. > 26°.

The old **Kelsey Bank** yielded much good ore, years ago, in funnel shaped pockets, not continuous.

No. 23. Little Dry Hollow Banks (see Local Map, fig. 14) are near the crest of the low hill dividing the middle from the north branch of the Dry Hollow. No. 1, is a small hole on a small outcrop reported to have yielded six to eight feet of sandy lump-ore, soon running out No. 2 consists of a group of small pits and trial shafts on a slight outcrop. Some ore was got from shafts A, B, and C. The appearances here are not favorable for future mining prospects.*

No. 24. The Dry Hollow Banks are the central figure in the broad expanse of outcrop which seems to fill the hollow and its three head branches, and to cover the dividing slopes, in many places if not continuously, north of the Railway. They are shown in map, fig. 29.

FIG. 29.



In the south-east corner of this map, the railroad curve ought to have been designated, the distance of the track from the principal excavation A, being less than 400 yards.

The cut on the south side of the township road is pictured by Mr. Harden, in fig. 28; that on the north of the road in fig. 30; and the road itself in fig. 31; the wash-ore in the R. R. cutting at the curve, south of the banks, is shown in fig. 32.

The Dry Hollow Bank, ½ mile north of the R. R., 2½ miles E. of

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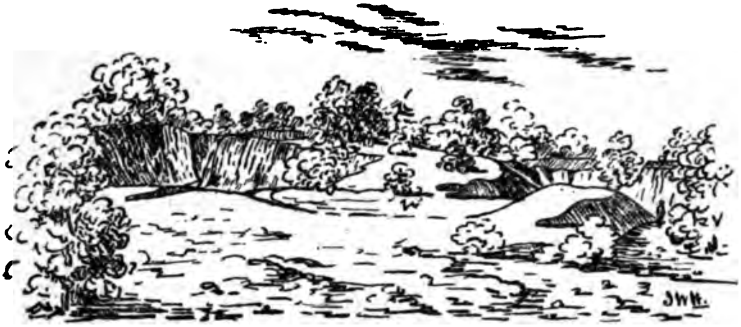
* Mr. Böcking reported some years ago that these works merely won small veins and top ore, while the body of ore is undoubtedly left under the little ponds, &c., at the foot of the hill. Good ore used to be raised from the Little Dry Hollow Bank, but efforts to "recover the vein" some few years ago failed, although the ore here rides to the top of the hill, where it is pipe-ore (as it also is pipe-ore on the northern side of the hill).

Warrior's Mark Village, is an extensive system of open cut excavations, from which great quantities of excellent ore have been got in past times. The term "system" is however inapplicable to the process of mining here employed, for it resembles rather the burrowing of animals. No one can estimate how much of the precious ore has been left untouched, for there are neither maps, nor records, nor traditions of the work.

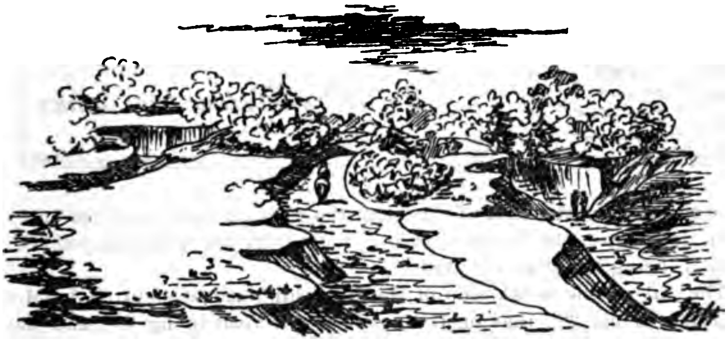
FIG. 30.



Part of Dry Hollow Bank. South side of Road.

The old miners merely say that the ore runs out against a bank of clay. But such reports are good for nothing; and even if literally true teach nothing, for they are sure to relate to single points, and fail of application at others. Fifteen years or so ago, some of the old pillars of ore were taken out by sinking shafts and driving short galleries at a few points. The ore is mostly wash-ore, that is fine ore disseminated through

FIG. 31.



Road to Warriors Mark through Dry Hollow Bank.

clay. The dip is southward (towards the great central synclinal) and deep workings and powerful pumps are needed, in future, south of the old shallow surface workings.

From Dry Hollow Summit Cut for the Railroad to the first shafts, a distance of about 400 yards, there is a decided outcrop. The shafts extend over 200 yards to the edge of the big open cut A, fig. 29. They seem to have gone down* through wash and lump ore 60 feet to water, which in all cases stopped the works. The lumps alone were carried to the furnace. The wash-ore was not valued then ; now it is merchantable. The sinking was done at random and ore was always got.

Mr. Platt's estimates on the ground are as follows :

$$\left.\begin{array}{rcr} 110\times40\times10 & = & 44{,}000 \\ 50\times15\times8 & = & 6{,}000 \\ 50\times15\times6 & = & 4{,}550 \\ 60\times25\times10 & = & 15{,}000 \\ 50\times10\times5 & = & 2{,}500 \\ 100\times10\times4 & = & 4{,}000 \end{array}\right\} \begin{array}{l} \text{76,000} \\ \text{cubic} \\ \text{yards of} \\ \text{excavation} \\ \text{done.} \end{array}$$

The main bank A, shows wash-ore of very variable richness from top to bottom, 50 feet. The shafts at B are reported 60 to 70 feet deep, through wash and lump ore. From shaft C, on the roadside, 60 feet deep, 1600 tons of excellent lump ore alone was selected for use.

About 300 yards north-east of the Banks, the railroad line has exposed a mass of lump and wash ore of excellent quality.

The **Old Red Bank** of Bald Eagle Furnace is on a continuation of the Dry Hollow deposit south-west, but higher up the hillside. It is shown in local map, fig. 19. Mining was confined to the surface ore which was sandy and without 'regular veins ;' but no one knows how the deposit of ore is to the deep.

The surface show between the Dry Hollow Banks and the Red Bank is not so heavy as where the old excavations were made ; but the deposit underneath is really continuous and unbroken, as is shown by the cuttings through the ridge made by the railway between the two localities. See fig. 19.

Here wash ore has been exposed for 100 to 125 yards along the track ; sometimes 10 feet thick resting on clay ; sometimes 20 to 25 feet of wash ore holding larger lumps. The varying thickness of the red clay and ore layers in this cut is an instructive example of what the miners found in their shafts. Some of the lumps weigh 300 to 400 lbs. Very few pieces of silex appear ; and on the whole, this deposit looks freer from silica than any in the valley. Little or no soil covering exists.

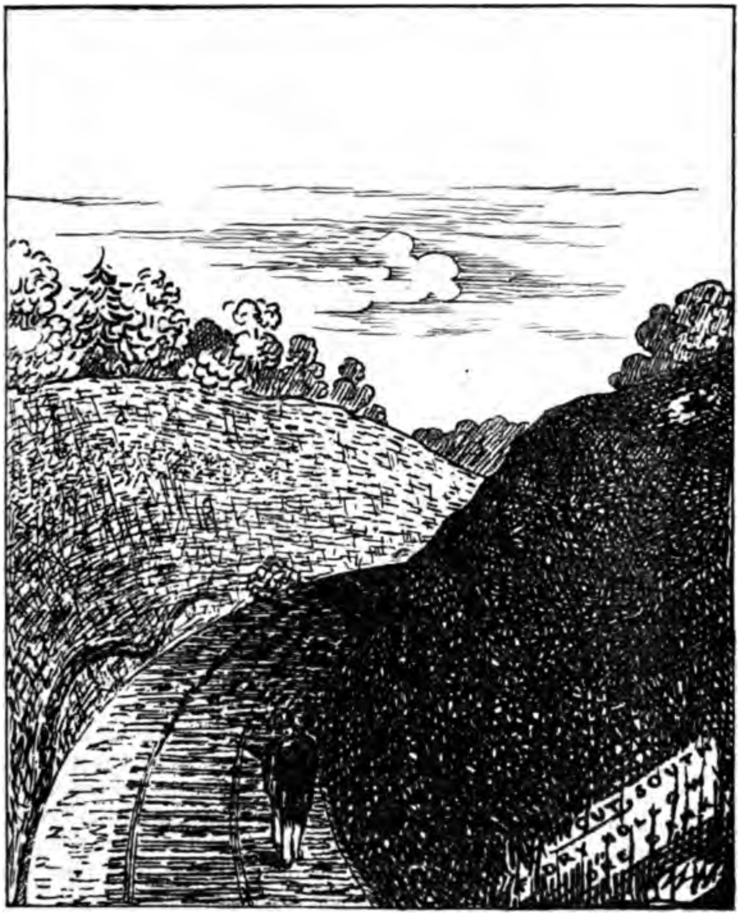
The Red Bank pits and shafts are very numerous, and all shallow. The ore when smelted alone, at Bald Eagle Furnace, made first class iron.

From the south-west end of the Red Bank to the north-east end of the Dry Hollow Bank is about 1000 yards. The breadth is 200 (say 150)

*25 years ago, more or less.

yards. The worked depth (to water) varies from 20 feet at Red Bank to 100 feet at Dry Hollow Bank. Taking an average of 10 yards, we have 1000 ×150×10=1,500,000 cubic yards of wash and lump ore. Discard one-half of the leaner interval between, and allow one ton to the yard in consideration of the size and quantity of lump ore, and we have 750,000 tons.

FIG. 32.



In our ignorance of the condition of things where the water stopped the old fashioned rude mining, it is impossible to say how near this estimate approximates accuracy.

No. 25, Bean Bank lies a mile to the S. West of the Dry Hollow Bank, where many tons of surface lump ore were scratched out and sent to Huntingdon Furnace; as was done in other places along this part of the range on the South Slope of Dry Hollow Ridge. No attention was paid to the great body of wash ore forming the deposit, and no effort to mine to the deep. A vast body of ore ground awaits future exploration and excavation, within a mile of the railroad. Quartz occurs in this ore bank.

No. 26, Bressler Bank, (see fig. 16) is a collection of small holes, on the north-west side of the ridge, in a ravine descending to the east branch of Warrior's Run, and distant from the railway, half a mile. About 2500 cubic yards of excavation seems to have been made in past years. The pits are fallen in, showing sandy wash ore in their sides. Eight feet of lump ore is reported as mined in this locality. No geological indications of the structure appear.

This completes all I have to say here of the Dry Hollow outcrop. For, although ore has been found further south-west along the south side of the ridge towards Warrior's Run, no mining has been done; and the Old Seat Bank, (No. 37,) is so out of line with the Banks above described, that it may be left for notice in connection with the ores west of Warrior's Run. But I shall describe, further on, the continuation of this range where it crosses Warrior's Mark Run and at the Huntingdon Furnace and Dorsey Banks.

I pass over, therefore, to the Cale Hollow (Kerr & Bredin, Hostler and Pipe-ore) Banks further south-east.

THE CALE HOLLOW RANGE.

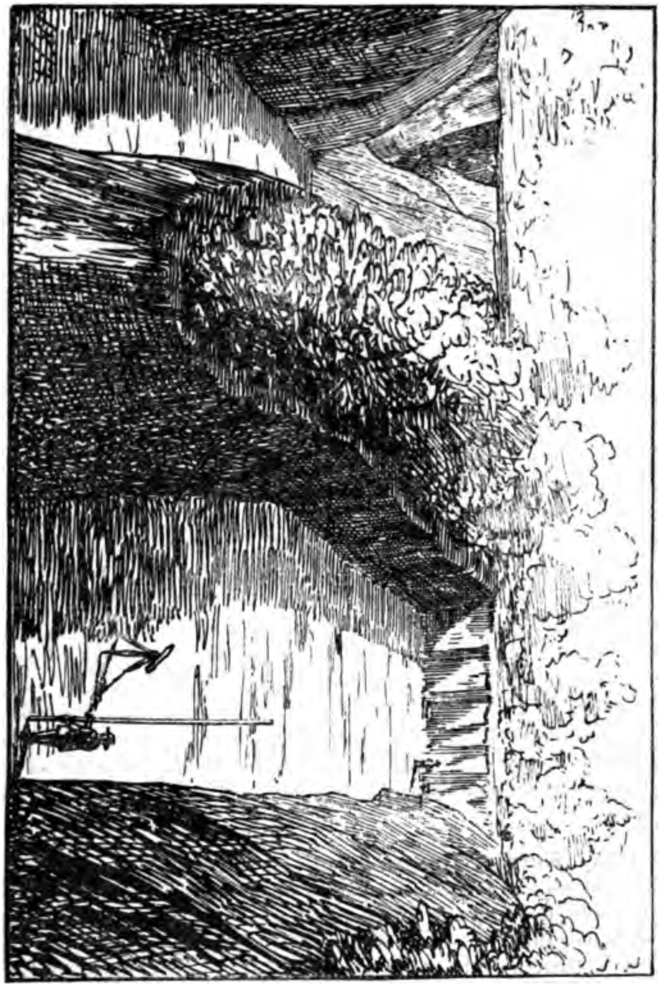
Cale Hollow is divided from Dry Hollow by Hickory Ridge, as shown in the Large Map; and its ores lie in a deeper and narrower synclinal than the ores in the gentle and wide synclinal of the Dry Hollow as shown by section CD. They are, however, ores once carried by the same limestone strata, and ought therefore to be of the same general character. It is therefore remarkable that so little pipe ore has been found in Dry Hollow, while an abundance of pipe ore characterises the Cale Hollow Banks.

No. 27. Kerr & Bredin Bank, (see local map, fig. 24, and wood cuts 33, 34, 35,) is a small excavation of about 5000 cubic yards, showing in its walls lump and wash ore, 25 feet deep. Much of the wash ore seems leaner than in other Banks. A shaft has been sunk for exploration in the bottom of the old cut, and the report of it is favorable to future mining on a systematic scale. (See wood cut, fig. 35.)

The ore from this bank won for itself a high reputation at the furnace. It was called "gun metal ore," and was said to bear a striking resemblance to the Bloomfield ore of Morrison's Cove, south of Holidaysburg in

Blair Co., from which was made by preference the ordnance of the U. S. Army during the civil war

FIG. 33.



Part of the Kerr and Bredin Bank, sketched by J.W.Harden.

Dr. Genth's analysis of the Kerr & Bredin ore, given below, when compared with Dr. Otto Wuth's analysis of Bloomfield ore, made June 9, 1871, compare as follows :

	Kerr & Bredin.		Bloomfield.
Ferric Oxide	70.67	Perox. Iron	78.63
Manganese Oxide	0.36	Manganese	0.29
Cobaltic Oxide	trace		—
Alumina	3.91		2.50
Magnesia	0.26		0.38
Lime	trace		0.34
Phosphoric Acid	0.19		0.134
Silicic Acid	5.48		7.02
Quartz	6.80		—
Water	12.33		10.71

The extra quartz determined by Dr. Genth, diminishes the percentage of iron oxide in his specimens, and reduces the percentage of iron from 55.04 (Wuth) to 49.47 (Genth). Otherwise the ores are strikingly alike.

The **Kerr & Bredin** Bank lies at the foot of the south slope of Hickory Ridge, one mile W. N. W., of the Hostler Bank. In a dry autumn Mr. Bocking was directed to sink south of the old cut, and to mount a pump. He reported a 12 inch "vein of ore" at 40 feet, and water at 44 feet. A tunnel-way was commenced in the direction of the old cut, which caved in, and the works were stopped.

The continuation of these ores along the foot of Hickory Ridge, on the north side of Cale Hollow, is proven by a range of "lively outcroppings." In some places the surface is sufficiently rich wash-ore. One or two pits (Bronstetter's) were worked, for Huntingdon Furnace, 1½ miles west of the Kerr & Bredin Bank, in "an irregular vein."

Northeastward the ores continue to show themselves to Half-moon Run, where "pipe-ore" is marked upon the large map. See Little Bank, below.

From a small cut at Eyer's, on the east side of Half-Moon Run, pipe-ore was raised many years ago. The limestone rocks at Eyer's house, 100 yards south of the spot, dip to the S. 30°, E. > 21°.

Another old pipe-ore locality shows now fair ore on the surface, near two small trial pits.

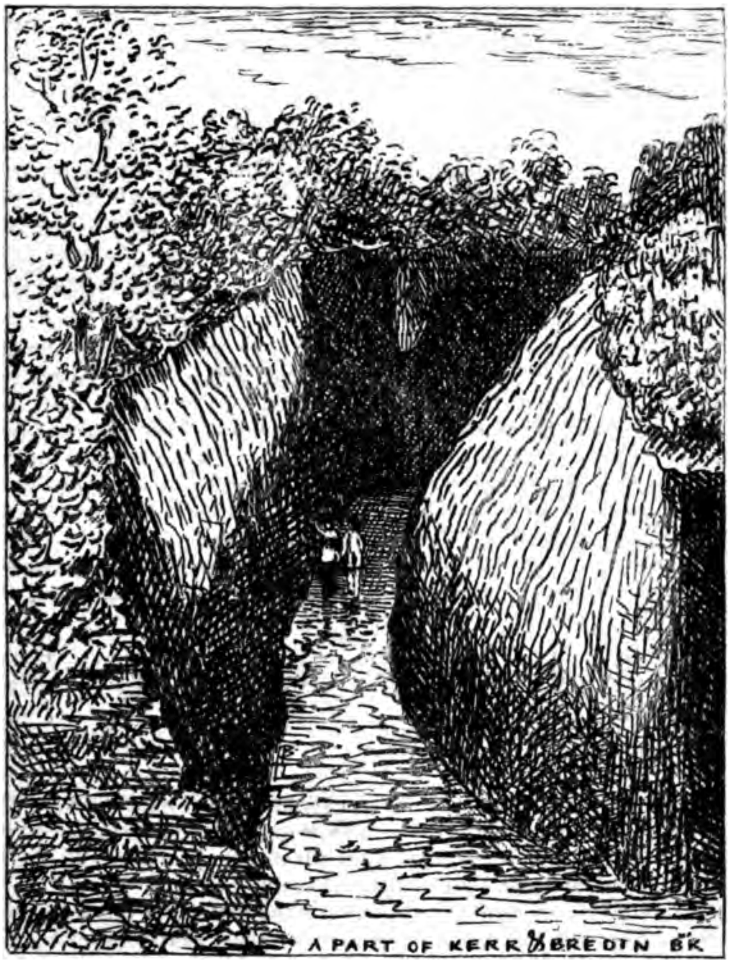
No. 28. Hostler Bank (see local map, fig. 26, and wood-cut fig. 36). This excavation occupies the northern slope of the Spruce Creek anticlinal ridge, as a large open cut, from which the ore was in old times hauled to Pennsylvania Furnace, two miles due east of it.

The recorded history of this important mine reveals the following features. Wherever the diggings were made they went down through "pipe" wash-ore which was occasionally mixed with lump-ore, to depths of 60 and 65 feet, in all the shafts.

One of these shafts passed through this wash-ore 65 feet, and then passed through a stratum of solid limerock, varying in thickness from 10 inches to 2 feet. Below this limestone lay lump "pipe" ore, into which the shaft was sunk 6 feet further and then the flow of water stopped its further descent.

From the bottom of the shaft a five inch auger hole was then drilled through a continuous bed of pipe ore to an additional depth of 39 feet.

Fig. 34.


A PART OF KERR & BREDIN BK

The percentage of iron in the pipe ore is uniform ; or varied only by the chemist's including in his analysis adherent or enclosed clay.

It is a constant feature of the Pipe ore banks of the southern range that they do not furnish the "lean ores," so-called, which are met with in the Banks opened along the more northerly and geologically lower outcrops of the "Barrens" in this valley. It has been the uniform experience at the Pennsylvania, Hostler, and other Pipe ore banks that shafts and borings have always passed through lump-ore, after having been sunk or drilled below water level. But as pumping apparatus on a sufficient scale has never been applied to such deep shafts and borings, they have in no case passed through the deposit of lump ore, the thickness of which is therefore still a matter of conjecture.

I give the history of these operations as an evidence of the insufficient extent to which the development of this iron-ore district has been carried; to show that only its surface has been scratched, but its deposits not mined. Regular, systematic, efficient operations are yet to be begun. They await the completion of the railroad and that demand for large quantities of ore from distant furnaces which is already become so urgent. The underground drainage all through the Valley is immense, and the largest bodies of ore, and especially of pipe-ore, can only be won with heavy pumping and systematic stoping.

The Hostler open-cut Bank must be sunk in air to the lower ores, and through them to the bottom floor of all; then with powerful pumps to keep the water down, the clay stripping above can be washed, and the heavy face of ore below can be stoped and the top stuff thrown back into the abandoned ground as the ore-face advances. As Mr. Bocking justly remarks, "35 feet of ore will well pay for stripping 65 to 75 feet" of clays above it. He adds, and I agree with him heartily: "The time for shallow digging and ground-hogging is pretty well past in these barrens, and the exploration of the richer banks may require in future preparations that will take some capital, and may need in some cases two or more years before yielding a return."

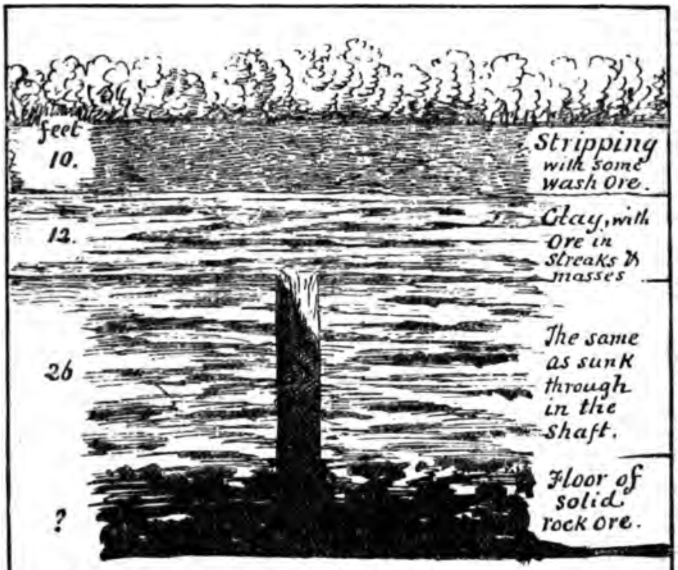
The Hostler Bank excavations measure about 120 × 50 × 10 = 60,000 cubic yards. The ore lies like that to be described in Pennsylvania Furnace Banks, as a mass of clay and wash-ore separated by ribs of undecomposed limestone. The walls are about 30 feet high, but the high northwest dip of the measures prevents this figure from being used as a datum of calculation. It only shows in a general way the depth below the sod to which the weathering action had gone, *as exposed by the miners.* The late sunk shafts passed alternate soft beds of ore and hard ribs of limestone, all on a steep dip; 38° to the N. 35° W. In a shaft at the northwest end of the open cut one shaft went down through 75 feet of wash-ore ground before striking the solid limestone rocks and water.

It is impossible from such data to estimate the future yield at this locality, but the amount of ore to be won must be very great. Nor is it confined to the neighborhood of the old works. The ore-belt runs on southwestward for at least five miles.

At the distance of 1,900 feet there are somewhat less than twenty old shafts in one group, quite forgotten until recently discovered by Mr. George Lyon. They were mostly shallow pits in the surface of the pipe-ore bearing clays; but some of them look as if they had been sunk to a considerable depth; and their number proves that the search for ore was remunerative even at that day.

This part of Cale Hollow is a wide, flat, slightly undulating, dry vale, every part of which shows a top-dressing of fine ore. It is a virgin district. Mr. Lyon sunk one trial-shaft in it, and struck an "ore-vein." There was a similar accidental discovery of another group of five or six pits from which some top-ore had been scraped. I have no doubt that a continuous belt of mining ground runs the entire length of Cale Hollow.

FIG. 35.


feet
10.
12.
26
?
Stripping with some wash Ore.
Clay, with Ore in streaks & masses
The same as sunk through in the Shaft.
Floor of solid rock ore.

A Section at Kerr & Bredin Ore Bank.

The **Red Bank**, 1¾ miles from the Hostler, on the same slope of the Spruce Creek Ridge, is old and disused, the ore in the top clays was stripped, but no attempt at deep mining was made. Another old bank in line with it, but across a little ravine issuing from the ridge, furnished some pipe-ore to Huntingdon Furnace. Still further west,* in a similarly situated bank, near Huntingdon Furnace, a vein of good, red-short ore was struck, and abandoned on account of water. On working one part of this pit the ore became too sulphureous to use. It will be again referred to after describing Bank No. 29.

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* 4⅓ miles from Hostler Bank.

The belt of Cale Hollow Ores may be traced northeastward with the same general character.

Little Bank, for instance, lies two-thirds of a mile northeast (near the Warrior Mark Pennsylvania Furnace Road), 1⅔ miles west of Pennsylvania Furnace. Here very rich top-washings cover a high flat area connected with Hickory Ridge. Seams of the ore penetrated the limestone rocks all the way down a 40 feet shaft, under which the main body of ore dips northward.

The **Eyer Bank** (already mentioned) is an old excavation one mile still further east, on the east side of Half-Moon Run.

Going on northeastward across a dividing ridge, the ore appears again along Tadpole Run, in Sleepy Hollow, and at the head of the Beaver-dams, for a distance of more than a mile. Years ago, some pipe-ore was raised, for Centre Furnace, east of B. Crane's, but the surface was merely scratched. At the Pennsylvania Furnace old surface-pits, sunk at the beaver-dams, the body of ore probably lies under the bed of the run and would require heavy pumping.

The "dry hollow" which carries the Valley of Tadpole Run on in a straight line northeastward, and is a geological prolongation of Cale Hollow shows plenty of out-croppings of ore, just as Cale Hollow does, and the ore is of the same kind—pipe-ore. In fact the ore belt continues to McAllister's and the School House cross-roads, eight miles northeast of the Hostler Bank, and far beyond the limits of my large map.

Between McAllister's and Pinegrove Mills, the country spreads out into a plateau two or three miles wide, through which runs the Brush Valley Anticlinal. Here, far beyond the east limit of my map, are the

Old Weaver Banks; two open-cuts and several shafts near them, abandoned years ago. No systematic mining was attempted in that early day, the work being done by the farmers. Tradition speaks of "ore veins" being reached, but probably too well watered for the natives to cope with them. "The ore lying around the holes is not a regular pipe-ore, but is mixed with liver-colored ore, and reported red-short." We have here, then, ores not belonging to the Hostler and Pennsylvania Pipe-Ore Bank system connected with the sandstones of the anticlinal, that is, ores belonging to the underlying limestone.

SPRUCE CREEK RANGE.

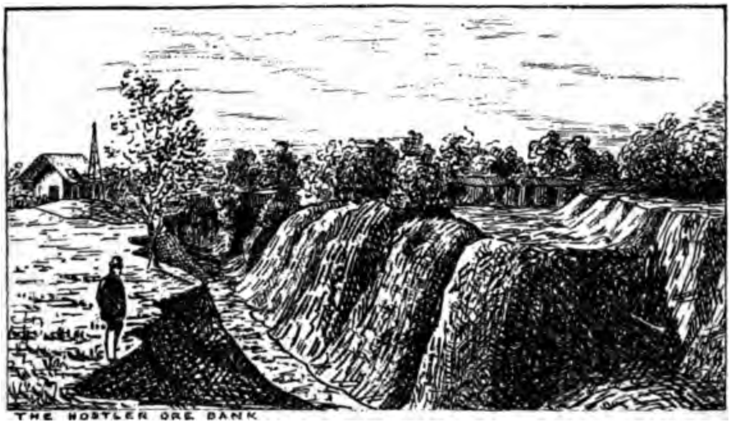
No. 29, Pennsylvania Furnace Ore Bank. For about fifty-eight (58) years Pennsylvania Furnace has been supplied with its stock from the extensive excavations on the gently-sloping south side of the anticlinal ridge facing Tussey Mountain; Spruce Creek, above the Furnace, flowing between the ridge and the mountain.

See local map, fig. 37, in lieu of further description; and the landscape sketches of the excavations, to illustrate their extent and character: figures 39, 40, 41, 42, 43.

The geologist can here study the theory of the formation of the Lower Silurian Brown-Hematite ores of Pennsylvania to great advantage. I know no better place, and few so good.

The ores are evidently not washings from a distance; neither from Tussey Mountain, nor from the present surface of the anticlinal ridge; nor from any formerly existing surface in past geological ages, when the surface stood at a much higher elevation above sea level. They are evidently and visibly interstratified with the soft clay and solid limestone layers, and obey the strike and dip of the country; the strike being along the valley, and the dip about 40° towards the southeast.

FIG. 36.



Thousands of minor irregularities prevail; the streaks of ore and masses of clay, are wrinkled and bunched, and thin out and thicken again in various directions. But all this irregularity is owing to the chemical changes of the strata, and to the changes in bulk of the different layers during the protracted process of solution and dissolution, during which the looser calciferous and ferriferous sandstone layers have lost their lime constituent, packed their sand and clay more solidly, and perhydrated their iron. In this long process cleavage-planes have been widened into crevices; caverns have been excavated; pools or vats have been created; precipitates of massive (rock and pipe) ore have been thrown down; and a general creeping and wrinkling of the country been effected. But the original general arrangement or stratification has been preserved; and those portions of the whole formation, which had but little lime, have been left standing as sandstone strata; while others having but little sand remain as solid and massive limestone strata; those which had an excess of alumina are now in the condition of streaks, masses, or layers of white or mottled clays; and only such as were properly constituted clay-sand-lime-iron deposits originally have so completely dissolved as to permit the lime to flow off, and the iron to consolidate into ore.

Every stage of this interesting operation, and every phase which it presents in other parts of the Appalachian belt of the United States, from Canada to Alabama, may be seen and studied in these old and extensive ore banks of Pennsylvania Furnace.

At first sight of the bank the ore deposit looks as if it were a grand wash or swash of mingled clay and fine and coarse ore grains and balls, occupying hollows, caverns and crevices in the surface of the earth and between the solid limestone rock; and some of it undoubtedly has been thus carried down into the enlarged cleavage partings of the limestones; and into sink holes and caverns formed by water courses; where it now lies, or lay when excavated, banked up against walls or faces of the undecomposed lime rocks. But as a whole the ore streaks and "main vein" of ore must occupy nearly the same position originally occupied by the more ferruginous strata after they had got their dip and strike. See fig. 40.

The ore is taken out with the clay, and hauled up an incline, by means of a stationary steam engine at its head, and dumped into a large washing machine, with revolving screens; whence after the flints and sand stones have been picked out, it is carried on an ironed tramway, to the bridge house of the Furnace. See fig. 43.

The ore forms from 10 to 50 per cent. of the mass excavated, and the small amount of handling makes the ore cheap.

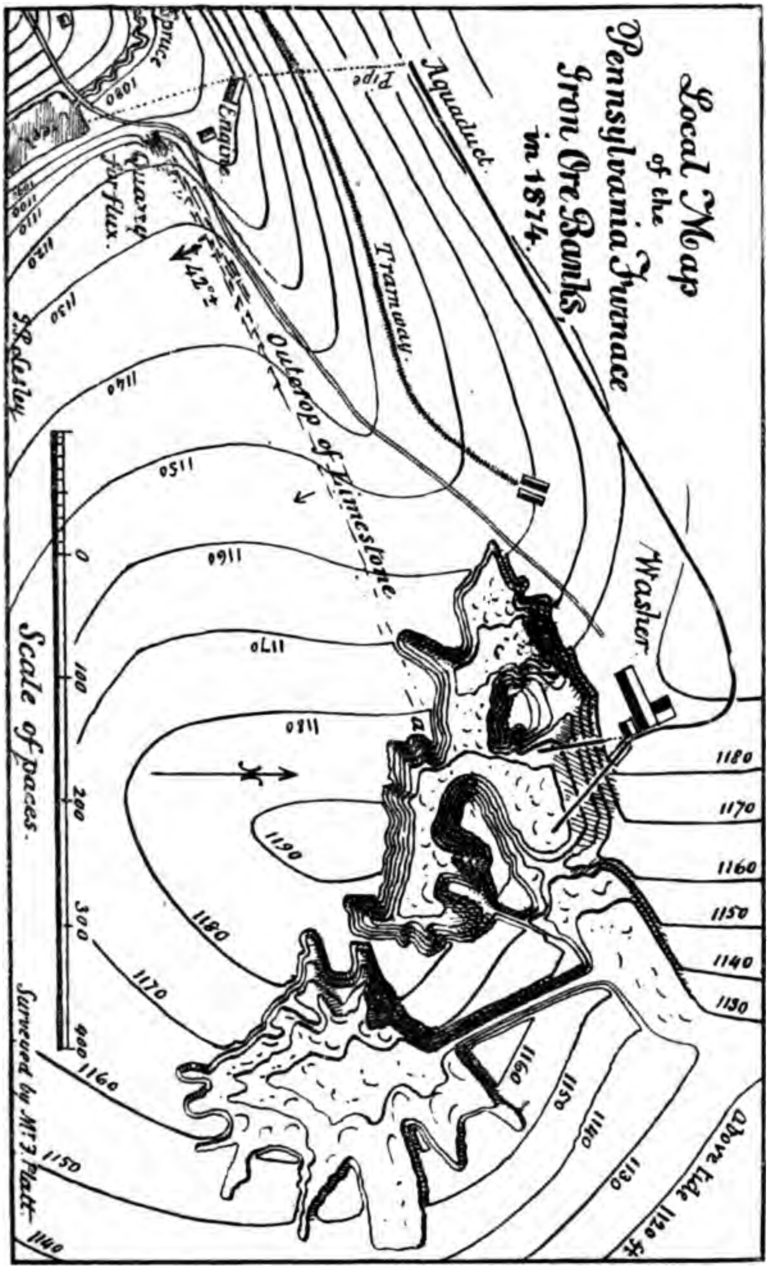
The floor of the excavation is about sixty (60) feet below the level of the wash machine.

Shafts sunk from 30 to 35 feet deeper, in the floor, to a permanent water level, have shown that other and even better ore deposits underlie the workings, covered by the slanting undecomposed lime rocks. This is an additional demonstration of the correctness of the theory above stated.

The upper ores will furnish stock for yet many years. After that, or in case more furnaces be erected, or distant markets call for the shipment of ore by railway, deep shafts or bore holes must be sunk to drain the underground, and the lower ores may then be lifted to an extent which can hardly be estimated now.

The prism of ore *in sight*, technically speaking, if calculated roughly from the areas exposed by the old and new open cuts, and by shafts sunk at various times and in various parts of the floor, gives several millions of wash-ore, lump-ore and pipe or rock ore. Thus taking the area exposed at say 550 × 450 yards, and the depth at only 15 yards, we have 3,612,500 cubic yards, which on washing would yield 602,000 tons of prepared ore.

FIG 37.

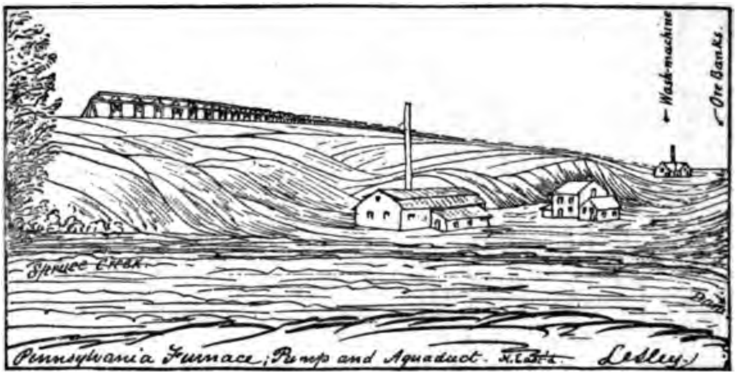

Local Map of the Pennsylvania Furnace Iron Ore Banks, in 1874.
Aqueduct
Pipe
Spruce
Engine
Quarry for flux
Tramway
Outcrop of Limestone
42°
Washer
a
x
Scale of paces.
0
100
200
300
400
Above tide 1120 ft
Surveyed by Mr. J. Platt
J. P. Lesley
1080
1090
1100
1110
1120
1130
1140
1150
1160
1170
1180
1190

Of this, about 100,000 tons have been passed through the furnace, yielding nearly 50,000 tons of neutral cold blast charcoal iron of the best quality, leaving 500,000 tons of ore to be excavated.

But this is only a portion of the deposit; for the ore ranges away beyond the high walls of the open cuts into the surrounding land an unknown distance. The large area stripped last year towards the northeast shows how extensive the deposit is in that direction.

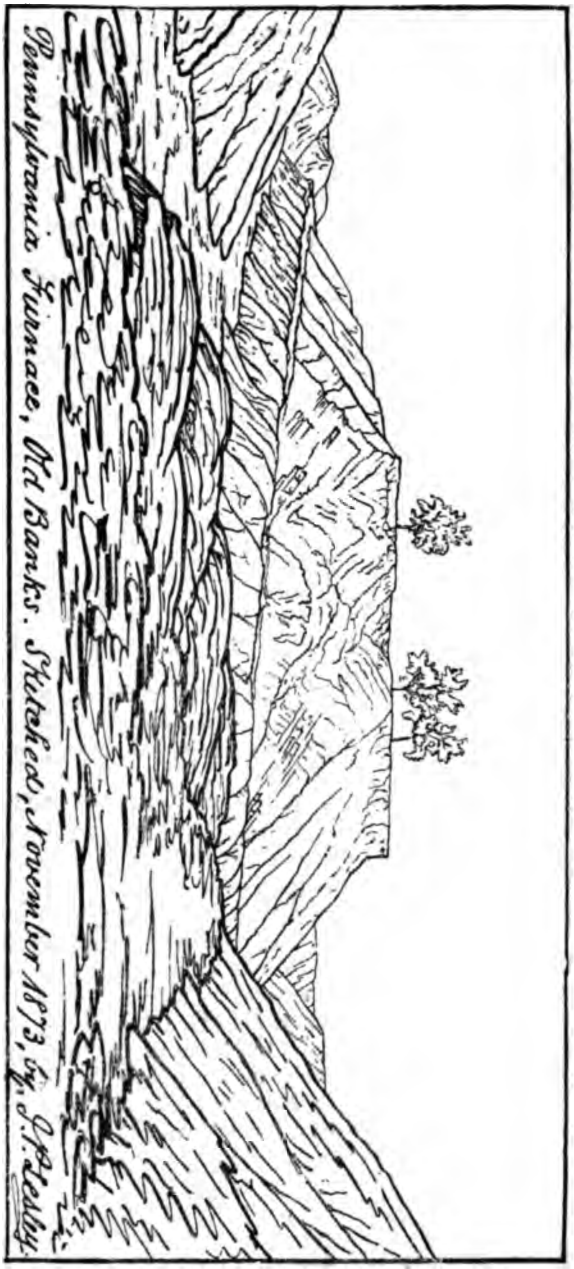
Add to this the great depths to which the ore is known to descend, and it seems to me certain that a million of tons is as probable an estimate as a half a million. Large quantities of ore are left standing between the hard limestone ledges exhibited in figure 40 (taken from *a* in local map fig. 38), and in figure 34, which is an enlarged view of the sharp promontory seen in fig. 33, sketched to show its geological structure. The dip of these limestones is to the S. 35°, E. > 35° to 40°; and they are exactly on range with the limestone outcrop along the road, at the quarry, and past the Furnace, as shown in fig. 37. Slight crumplings of the limestone vary the dip from 18° to 65°; but these are due either to movements in the yielding ore mass or to a deception caused by mistaking cleavage planes for bed plates. No such variations are apparent at a distance from the banks, the whole limestone formation descending uniformly beneath the foot of Tussey Mountain with a dip of something under 40°.

FIG. 38.



The pictures figs. 41 and 42 are views of the deep cut looking east from *a* in local map fig. 37. The view in fig. 43 is taken looking northward into the main ore bank, from near *a*; and it shows the new incline, the washing house, and the ridge above it, along the crest of which the aqueduct is carried on tressels, for 2000 feet. Fig. 38 shows the end of the aqueduct where it is mounted by the pipe leading up the hill-side from the double Worthington pump in the engine-house, fed by another pipe from the dam. Behind the hill seen in fig. 43, in a hollow on a level with the northeast end of the banks, is the settling-dam.

FIG. 39.


Pennsylvania Furnace, Old Banks. Sketched, November 1873, by J. P. Lesley.

The height of the walls of the various excavations may be seen by reference to the ten foot contour lines in fig. 37. These also show that the ground now so deeply excavated once formed a high divide between a vale descending southwest to Spruce Creek, and a corresponding but shallower vale descending northeast to the settling-dam hollow. It looks as if the ore once filled both these vales, but has been excavated by the natural drainage into Spruce Creek, from the one which descends in that direction, and, perhaps from the valley of Spruce Creek itself, down to and beyond the Furnace.

The entire walls of the cuts are of wash ore, and it is all torn down and taken to the washing machine. But the tops of pyramids of solid pipe ore are exposed in the floor, and some reached to, or nearly to the sod above. At one of the deepest places in the floor, 60 feet below the sod a shaft was sunk 40 feet further through solid pipe ore, and then limestone, and was stopped by water. Water does not stand in the present floors on account of the free circulation, at a still lower depth, through crevices and caverns communicating with Spruce Creek, which itself issues from a cave.

The books at the Furnace show as an average for some years, 6 tons of wash ore to 1 ton of ore; 2 tons 1 cwt. of ore to 1 ton of iron; and $2.25 per ton of ore delivered at the Furnace, represents the cost of mining, inclusive of all expenses.

I shall give in an appendix, the opinion of Mr. Harden on some practical points which I requested him to study, for which purpose he visited some of the Banks described above.

Outcroppings of ore occur east and west of the Pennsylvania Furnace Banks on the southern slope of the anticlinal ridge facing Spruce Creek and the Tussey Mountain; but no excavations have been made, because sufficient stock was always procurable at the Banks near the Furnace. It is not to be supposed, therefore, that equally large and important deposits may not be exposed by future systematic mining operations, when the completed railway shall make demands on this ore belt for supplying the furnaces of Eastern and Western Pennsylvania.

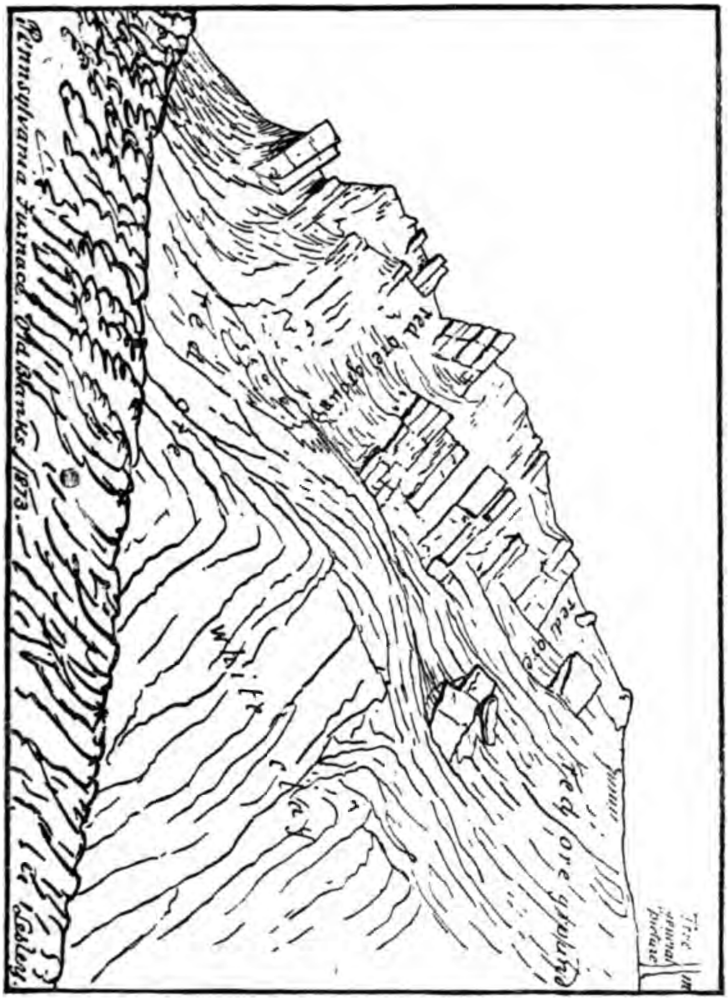
Some of these surface-shows of ore are near the top, others near the bottom of the hill slope. The ore surface is commonly high up on the slope, or on the flat rolling back of the anticlinal ridge.

John Ross has in his fields, north of Pinegrove Mills, (miles east of Pennsylvania Furnace,) an old funnel shaped hole, from which very rich pipe ore was taken, and more can be seen in its sides, but no surface-show; and I have no data on which to base an estimate of quantity. The ore was sent to Monroe Furnace; was rich; but very red-short: lumps of pyrites being visible in the bombshell ore lying about the hole; which is also coated with white sulphates.

Surface ore can be traced all the way from Ross' to Pennsylvania Furnace, but no search underground seems ever to have been made or called for.

In the other direction, down Spruce Creek, south-west of the Furnace, a few outcroppings on the surface appear, but lie neglected for the same reason. A few trial-pits seem to have been sunk near the school house, and near Mr. Geo. Lyon's mansion, south of the turnpike. Large pieces of pipe ore lie in the east corner of Mr. Thos. Lyon's fields, at the foot of Tussey Mountain. Ore has also been noticed in Mr. Stewart Lyon's north fields.

FIG. 40.



All the above are on the south slope of the anticlinal of Brush Valley, facing Tussey Mountain. The anticlinal may be studied where the limestone rocks are seen dipping both ways (N. W. and S. E.) in the end of the hill at the Furnace, and in the railway rock-cuts as the line makes its semicircle down Half Moon Run and up Spruce Creek and Tadpole Run.

Three miles further down Spruce Run a pipe ore bank was commenced on the south slope of the Anticlinal, to supply works erected at the mouth of Spruce Creek, for a patent process to convert the ore directly into wrought iron; but the patent process failed and the mine was never worked. It sufficed to show that the ore belt or outcrop follows the ridge along the north side of Spruce Creek towards the Juniata, but coalesces with that of the Cale Hollow, or north dip, beyond Huntingdon Furnace, and sinks beneath the surface, for no trace of it is found in the Little Juniata River section, where the Canoe Valley anticlinal may be seen replacing this of Brush Valley.

Returning thus to Warrior's Mark Run, and the neighborhood of Huntingdon Furnace, I have little to add to finish this report, except concerning an ore belt, west of the Run, on the south slope of the ridge in line with the Dry Hollow Banks. But before speaking of it, I shall give the following section up Warrior's Mark Run:—

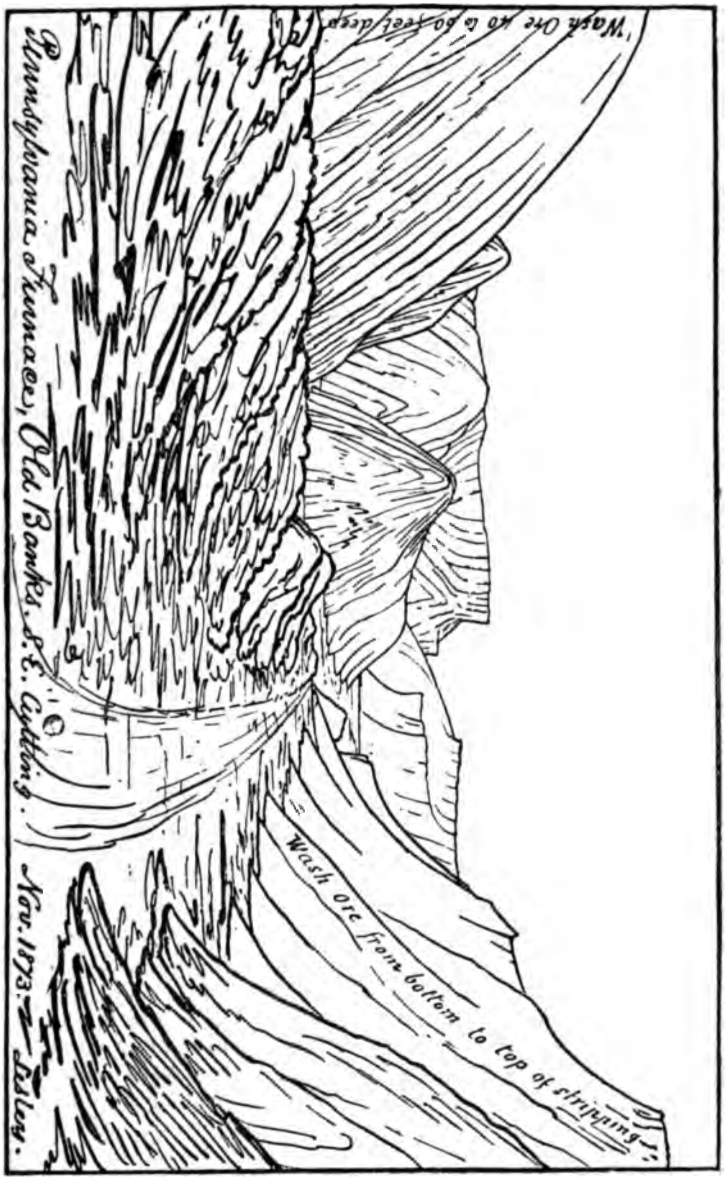
At the mouth of Cale Hollow, in the north dipping rocks of the Spruce Creek Ridge anticlinal, and 150 yards east of the mill-dam, or a mile east of Huntingdon Furnace, there is marked on the map an old pipe-ore bank, now fallen in. Lime rocks here dip N. 30° W. > 50°; but, by the road-side, 300 yards to the west-southwest only 38°; and in the hill-side, 650 yards to the west-northwest, 12° in the other direction S. 30° E. The Old Seat Bank, No. 30, is 1,100 yards distant (up Warrior's Run towards the N. N. W.) from this old bank. The Cale Hollow is thus seen to be synclinal, and, allowing for the different strength of dips observed there can be no reasonable doubt that the same ferriferous limerocks out-cropping here outcrop also at the Old Seat Bank; and I have so drawn the Section A.B.

The ore at this old bank is reported to have been extraordinarily charged with sulphur; but I could not learn exactly in what form.

No. 30. The Old Seat Bank, on the east bank of Warrior's Run, 2½ miles below where the railway crosses the run (at Warrior's Mark), is an old open cut with ore in its floor, abandoned many years ago for want of pumping machinery of adequate power. What little liver-colored ore is visible, looks lean, and much flint lies about. The area of the cut may be 4000 square yards. Water stands in it to within 10 or 12 feet of the top. It has been worked to a depth of 40 feet. About 30,000 cubic yards of ore-ground has been taken out. Although much liver colored ore like Pennington ore lies about, no pieces of sandstone are visible; but a good deal of flint is among the ore, as at Pennsylvania Furnace Bank. Not much surface-ore shows in the neighborhood.

In the gap of the Dry Hollow Ridge, six hundred yards higher up the

Fig. 41.


Pennsylvania Furnace, Old Banks, S.E. Cutting. Nov. 1873. J. P. Lesley.
Wash Ore 40 to 60 feet deep
Wash ore from bottom to top of stripping

run, limerocks crop out, dipping also S. 30° E. > 9° ; and 300 yards further, sandy limestones, S. 30° E. > 10°. 500 yards further up the run, pipe-ore is reported, ploughed up in the fields. This belongs to an ore-bearing strata about 700 feet lower in the formation than the ore horison at the Old Seat Bank. The dip is continuous and equable ; there can be no mistake. 500 hundred yards still further up the run, at the forks of the road, still lower sandy limerocks are seen dipping the same way, S. 30° E. > 13°. Other exposures occur in this interval dipping also S. 30° E. > 13°. No dips are noticed in the next 1000 yards, to the toll-gate and cross-roads and forks of the Creek ; but there is no reason no doubt that a southeast dip fills the interval, becoming ever more gentle.

Five hundred yards southwest from the toll-gate, and 50 yards off the road (towards the northwest) on land 70 feet above the water, is an old deserted pipe ore bank 50 × 10 yards. This lies just 1000 yards due northwest of the pipe ore last mentioned as ploughed up in the fields ; and if a continuous southeast dip of 10° be *supposed*, we should find in it an evidence of a third and still lower pipe ore horison, 550 feet below the second and 1250 feet below the first, or Old Seat ore horison. But it would be very unsafe to consider this the simple state of the case. The place where ore was "ploughed up over a space of 600 yards" is worthy of a thorough investigation, but the surface show is slight. The other locality where lumps and pipes of solid ore were got 25 years ago from the open cut and underground works, is reported to be rich still. None of its wash ore was taken away.

This place is very important. It proves conclusively that pipe ores occupy a *geological* range of at least 1250 feet of the Lower Silurian Formation. And these exhibitions on Warrior's Run connect the rich Dry Hollow Group of Banks already described, with the Huntingdon Furnace and Dorsey Group next to be described.

The toll-gate is only 800 yards down the run from where the railway crosses it. And the southeast dipping Beck and Town Bank ores (Nos. 4 and 5) are only 400 yards further up. The Beck and Town ore horison therefore underlies the toll-gate ore rocks (unless there be some concealed disturbance in the interval), at a *geological* depth of at least 1200 feet, and probably 1500 feet. For there are 20° dips (to the southeast) in the railway cut, and 35° dips in Warrior's Mark Village. If I am anywhere near the truth, the Pennington Range ore horison (Becks, Town, &c.) underlies the Cale Hollow Pipe Ore horison at a *geological* depth of 2500 to 3000 feet; which may well explain their different qualities. And this result is in harmony with features of my cross-sections AB and CD.*

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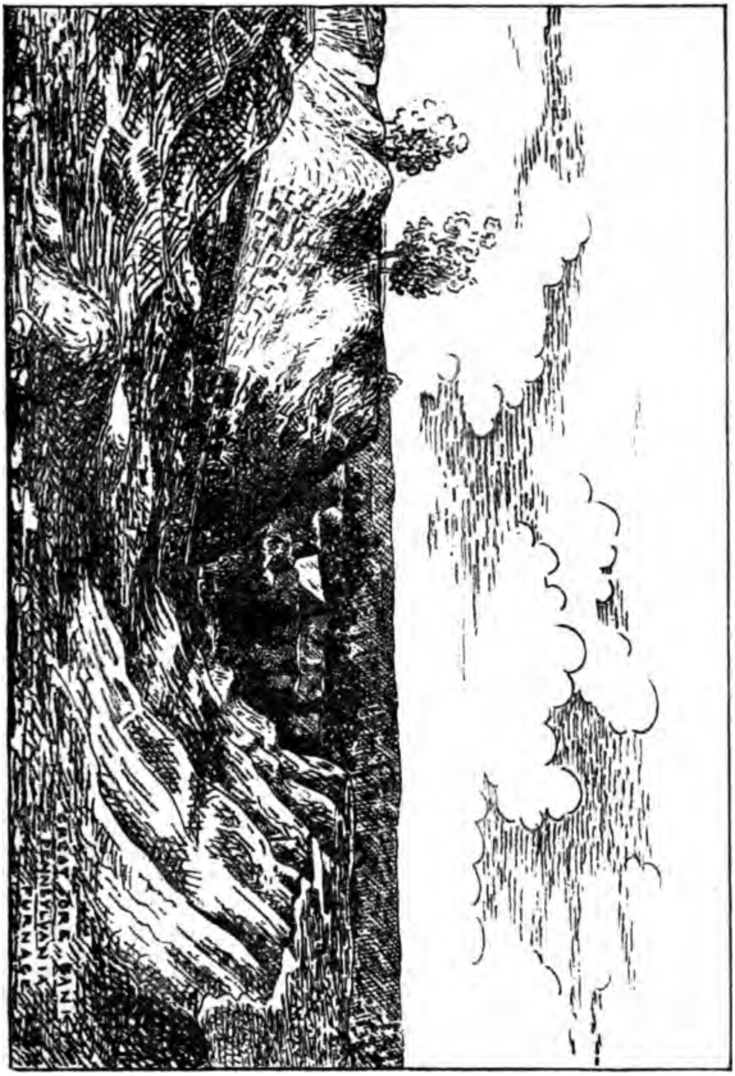
* The Pennington and Lovetown ores being on the same geological horison, and there being a breadth of limestone outcrop (dipping S. 30° E. > 50°), between Lovetown and the Bellefonte fault at the foot of Bald Eagle Mountain, at least 700 yards broad, we have about 5000 feet of Lower Silurian measures visibly exposed underneath the Cale Hollow (= Pennsylvania Furnace Bank) ore horison. Adding to this the 2500 feet of limestones between Pennsylvania Furnace bank and the foot of Tussey, and we have a total thickness of Lower Silurian Limestones from the bottom of No. 111 (the Hudson River Slate) down to the jaw of the Bellefonte Fault, of 7750 feet; a very great thickness; but quite in harmony with all that we know of the Trenton, Black River, Bird's Eye, Chazy and Calciferous in the Great Valley of Reading, Harrisburg, Chambersburg, Winchester and Knoxville. This, so far as I know, is the first approximately accurate measurement of these formations in mass south of their New York outcrops, which are very thin in comparison with these.

No. 31, Huntingdon Furnace Banks. These lie along the southerly slope of a prolongation of Dry Hollow Ridge, west of Warrior's

FIG. 42.



Run, and within a circle swept around Huntingdon Furnace with a radius of two miles, as shown on the land-map. The Dorsey Banks are outside this circle, but are excavated in the same belt of outcrop. The outcrop is very broad because, as we have just seen along Warrior's Run, the southeast dip is very gentle, about 10°. This has allowed a very large dissolution of the ore-bearing rocks.

The **Wilson Bank** is two miles west of Warrior's Run; no ore has been found in this interval, the slopes being sandy. Here limestone begins to come in, overlying the sandstone, and ore-bearing clays take possession of the surface. This sandstone has been mistaken for the Calciferous Sandrock; but must be one of the numerous intercalations of sand in the great limestone series.

The **Keefer Banks** follow, in the next half mile, and, although exhausted as to the wash ore of the outcrop, can be mined to the deep if proper pumping apparatus be mounted to keep the underground water down.

Fig. 44 gives a local map of these excavations, which severally measure, as they come in order along the line of Mr. Platt's survey :—

a.	*	130 × 30 × 8	=	31,200	cubic yards.
b.	*	160 × 35 × 8	=	44,800	"
c.	†	40 × 25 × 10	=	10,000	"
d.	‡	120 × 40 × 8	=	38,400	"
e.	§	100 × 40 × 8	=	32,000	"
f.	§	30 × 30 × 5	=	4,500	"
Total excavation, say,				161,000	cubic yards.

No. 32, Dorsey Banks, see fig. 44.

These works lie just outside the two mile circle around Huntingdon Furnace Stack (see Land-line Map), and are used for Barre Forge, distant three miles due west on the Little Juniata River; the nearest distance to the river by the Township line in a southwest direction being two miles.

There is first an open cut on the south side of the road, see fig. 44, measuring 65 × 25 × 6 = 9,750 cubic yards of excavation, with wash ore in the walls. Then, a shallow open cut, ten or twelve feet deep, 75 × 30 × 4 = 9,000 cubic yards, the floor being everywhere wash ore.

The Main Bank, in the southwest corner of fig. 44, is divided by a slide of the southeast wall into two open cuts, 200 × 70 × 15 = 210,000 cubic yards, with wash ore walls and floor (now generally 30 feet deep), but excavations have been made much deeper.

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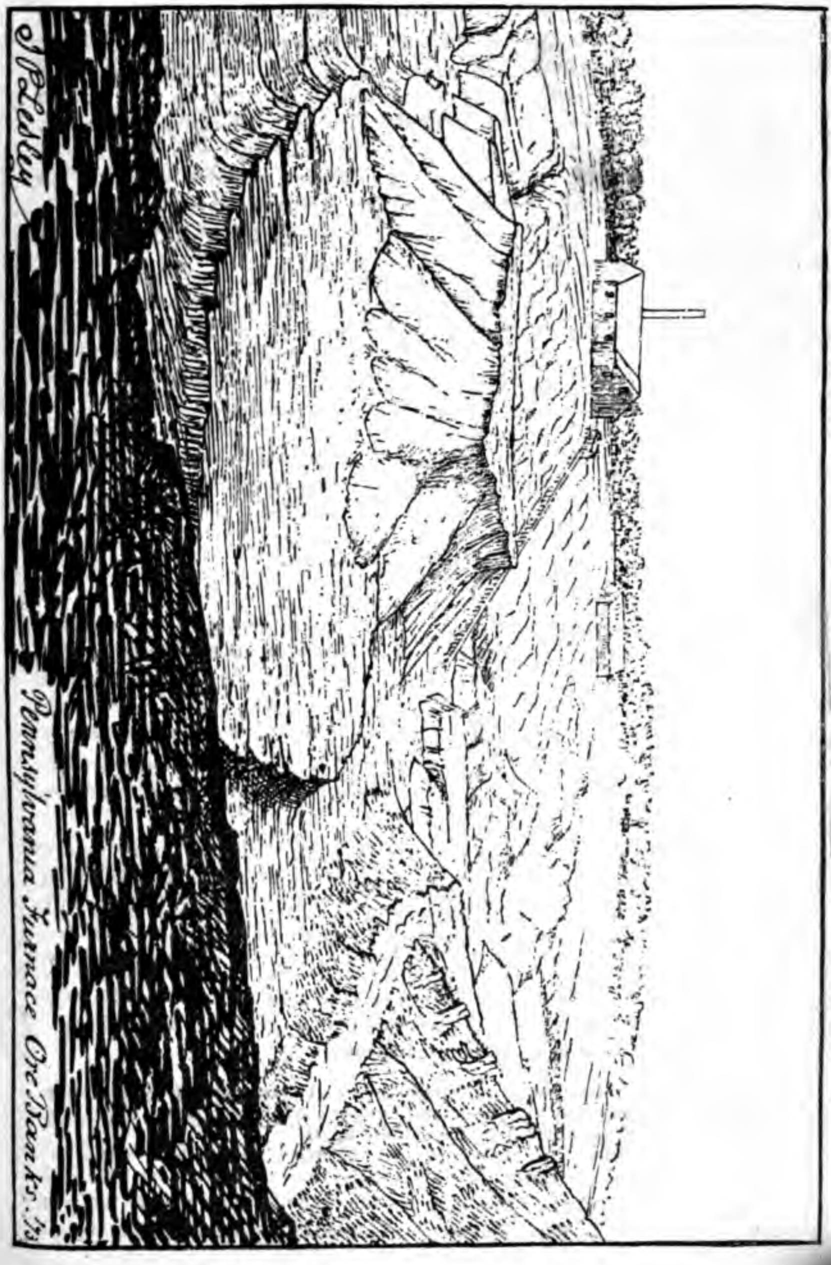
* These lie south of the road, on the large map. Eight yards is taken as the average depth of both, but they may have been worked deeper. Wash ore forms the walls.

† Also south of the road and beyond the limits of fig. 44.

‡ North of the road, at the northeast corner of fig. 44. It has not been worked for years. Wash ore forms the walls.

§ North of the road, and of the Dorsey Bank, fig. 44. Both have fallen shut. Wash ore forms the walls.

FIG. 43.



From the northeasternmost Huntingdon Furnace Diggings to the last Dorsey Digging is a stretch of about 2000 yards, with ore shows filling up the intervals between the banks. There is a maximum breadth of 500 yards. But if half that be adopted for an estimate, we have an area of wash ore here equal to 100,000 square yards, in all respects like that of the Dry Hollow Bank district (on the same range) described above, and representing, at least, one or two millions of cubic yards of ore ground, besides whatever deeper deposits of pipe ore exist.

As in Dry Hollow, so here much lean ore is mingled with the rich, and much dead stripping will be required in places.

There is this distinction: the ore of the barrens, that is the liver-colored and more sandy ore ranges along the northwestern side of the belt of outcrop, up the hill-side; pipe ore characterises the down hill, or southeastern side of the outcrop. The main bank is wholly in the top or wash ore covering, and has merely revealed the principal deposit of rich rock ore and pipe underlying it. Those who worked the pit describe a layer of ore 6 to 8 feet thick as apparently creeping downhill, overturned, and covering itself. What this description means I do not know. The ore makes excellent iron.

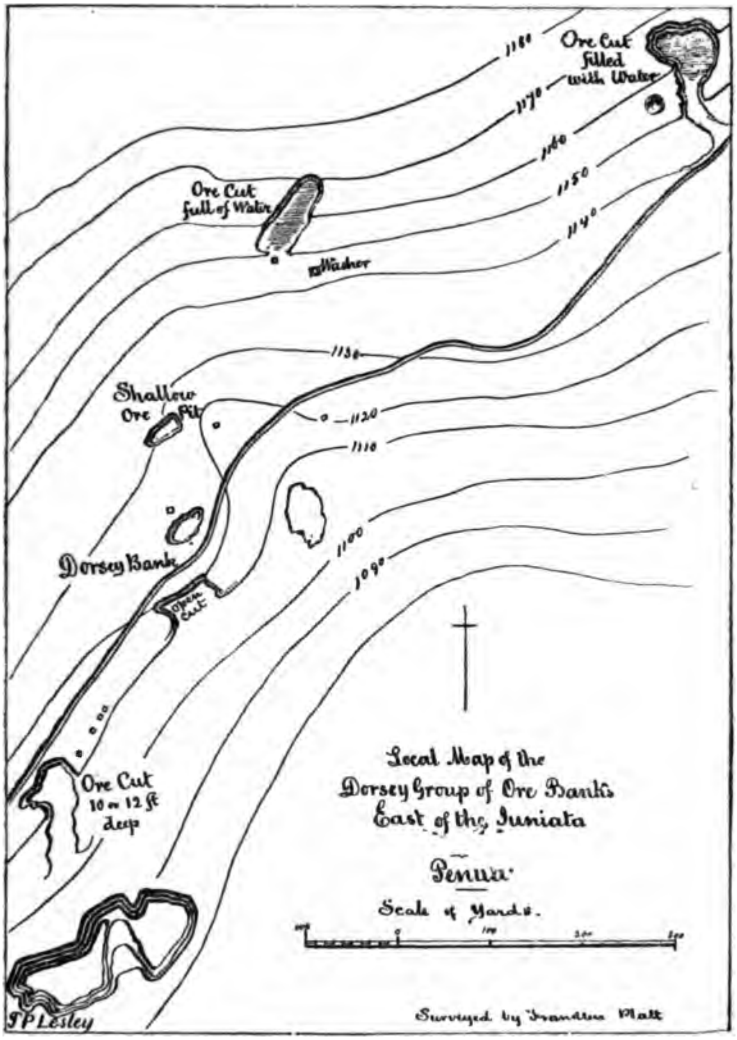
It is unnecessary for me to say that the ferriferous limestones described in the above details, and crossing the river (S. W.) into Sinking Valley, carry the ore ground outcrops with them, and that these have been mined to some extent at various places south of Barre Forge, yielding both rich and lean wash ore, and rock and pipe ore, of the same general character.

The same statement holds good as to Canoe Valley, although its narrowness does not permit its anticlinal to bring the lowest horison of ore to the surface.

In Sinking Valley the two sides of its dying anticlinal bring the ore outcrops together about three miles south of the river. The following are some of the ore banks: on the south side, Pine Hill Bank (½ mile from the river); Moore's Pipe Ore Diggings (1 mile); Galbraith's Pipe Ores (1½ mile); Robinson's Bank (2½ miles). On the northwest side are Gentzhammer's and other outcrops.

It is a serious question why mines of Brown Hematite Iron Ore have not been opened on the Juniata River above the mouth of Spruce Creek. This question seems to be answered by my section along the river, fig. 1. It is evident that the horison of the Pennsylvania Furnace or Cale Hollow ores scarcely rises on the back on the Canoe Valley axis to the level of the valley bed, and is immediately carried down again by the synclinal of Canoe mountain. It is then visible in Sinking Creek Valley, as just stated. Whether any large quantities of ore underlie the river bed below Union Furnace and above Spruce Creek Station remains to be determined by future trial shafts along the line of the Pennsylvania Railroad.

FIG. 44.



INVESTIGATION OF IRON ORES AND LIMESTONES FROM MESSRS. LYON, SHORB & CO'S IRON ORE BANKS ON SPRUCE CREEK, HALF MOON RUN AND WARRIOR'S MARK RUN, IN CENTRE, BLAIR AND HUNTINGDON COUNTIES, PA.

By F. A. Genth.

(*Read before the American Philosophical Society, February 6th,* 1874.)

NO. 1. EAST PENNINGTON BANK.

The greater portion of thirteen specimens, received for examination, was compact, dull, of various shades of brown and had like No. 1 an admixture of dark brown pitchy ore; other portions were porous and had the cavities lined with botryoidal fibrous brown limonite, others were stalactitic. Some of the ore had lost a part of its water of hydration and had changed into turgite and even into hematite. Many of the pieces showed a considerable admixture of manganese minerals, such as wad, minute quantities of pyrolusite and perhaps psilomelane, some contained a large quantity of rounded grains of quartz.

An average of the whole showed the following composition:

Ferric oxide	=	65.88	=	44.77 Metallic Iron.
Manganic oxide	=	6.00	=	4.18 Metallic Manganese.
Cobaltic "		0.34		
Alumina		trace		
Magnesia		0.26		
Lime		trace		
Phosphoric acid		0.22	=	0.097 Phosphorus.
Silicic acid		6.38		
Quartz		7.87		
Water		13.05		
		100.00		

100 Iron and Manganese contain 0.197 Phosphorus.

NO. 2. WEST PENNINGTON BANK.

Five specimens were submitted for examination. The ore was mostly of various shades of yellowish brown to dark hair-brown and without lustre; in some was an admixture of a dark blackish brown ore with subconchoidal fracture and a resinous lustre; some portions had a slight waxy lustre, others were earthy and dull. It was amorphous, but in places the cavities were lined with a coating of brown fibrous limonite. On being breathed upon, it developed a strong argillaceous odor.

An average of the five specimens contained :

Ferric oxide	=	70.93	=	49.65 Metallic Iron.
Manganic oxide	=	0.38		
Cobaltic "		trace		
Alumina		2.81		
Magnesia		0.14		
Lime		0.08		
Phosphoric acid		0.37	=	0.16 Phosphorus.
Silicic acid		4.38		
Quartz		7.91		
Water		13.00		
		100.00		

100 Iron contain 0.32 Phosphorus.

No. 6. RUMBARGER BANK.

A sample of ore was taken from a pile alongside of the Bank. It is mostly amorphous and compact, also somewhat porous, and has the cavities lined with a thin coating of fibrous limonite ; the cavities are also coated with red ochre and at times with yellow ochre.

The composition was found to be as follows :

Ferric oxide	=	74.16	=	51.91 Metallic Iron.
Manganic oxide		trace		
Alumina		3.06		
Magnesia		0.24		
Lime		trace		
Phosphoric acid		0.36	=	0.158 Phosphorus.
Silicic acid		6.11		
Quartz		3.94		
Water		12.13		
		100.00		

100 Iron contain 0.30 Phosphorus.

No. 11. LYTLE BANK.

The sample received for examination consisted mainly of amorphous compact brown ore, intermixed with fine fibrous limonite. The fibres are from ¼ to ½ of an inch in length and form botryoidal coatings ; sometimes divergent. The outside covered with yellowish ochreous ore.

The analysis gave :

Ferric oxide	=	82.00	=	57.40 Metallic Iron.
Manganic oxide	=	trace		
Alumina	=	1.94		
Magnesia		0.17		
Lime		trace		

Phosphoric acid		0.37	=	0.16 Phosphorus.
Silicic acid		2.98		
Quartz	=	0.44		
Water	=	12.10		
		100.00		

100 Iron contain 0.278 Phosphorus.

No. 14. BULL BANK.

The samples for investigation, five in number, were taken from piles of ore taken out about thirty years ago. One consisted of a beautiful fibrous limonite of a pale hair-brown color and silky lustre, much resembling that from the Lytle Bank, but of fibres two inches in length. The others represented the amorphous ores. They are compact, of various shades of brown, without lustre; they contain more or less cavities, partly filled with ochreous ore of a yellowish or reddish color. The amorphous ores have, on being breathed upon, a strong argillaceous odor.

a. Pure Fibrous Limonite.

Ferric oxide	=	81.48	=	57.04 Metallic Iron
Manganic oxide	=	0.07		
Alumina	=	0.49		
Magnesia Lime	}	traces.		
Phosphoric acid		0.08	=	0.035 Phosphorus.
Silicic acid		3.98		
Water		13.90		
		100.00		

100 Iron contained 0.061 Phosphorus.

b. Average of the five Samples.

Ferric oxide	=	74.85	=	52.40 Metallic Iron.
Manganic oxide	=	0.29		
Cobaltic oxide		0.21		
Alumina		2.42		
Magnesia		0.12		
Lime		trace.		
Phosphoric acid		0.24	=	0.105 Phosphorus.
Silicic acid		4.15		
Quartz		5.92		
Water		11.80		
		100.00		

100 Iron contained 0.20 Phosphorus.

No. 15. Pond Bank No. 1.

Two of the four specimens received were of a dark brown porous amorphous ore with very little lustre, more or less mixed with yellowish and reddish ochreous ore; the third piece was of a paler brown and contained small quantities of fibrous ore, the fourth was an ochreous ore of a pale brown and yellowish color. An average of the four samples contained:

Ferric oxide	=	78.68	=	55.08 Metallic Iron.
Manganic oxide	=	0.42		
Cobaltic "		trace.		
Alumina		2.89		
Magnesia		0.20		
Lime		trace.		
Phosphoric acid		0.16	=	0.07 Phosphorus
Silicic acid		3.17		
Quartz		1.71		
Water		12.77		
		100.00		

100 Iron contain 0.127 Phosphorus.

No. 16. Red Bank No. 1.

Five samples of ore received. It is generally an amorphous compact ore, with a considerable admixture of sand. Some is more porous, and has the cavities lined with fibrous limonite, and more or less filled with clay. Emits, when breathed upon, a strong argillaceous odor. Part of the specimens had lost a portion of their water of hydration.

The analysis of an average sample gave:

Ferric oxide	=	65.44	=	45.81 Metallic Iron.
Manganic oxide	=	0.13		
Cobaltic oxide		trace		
Alumina		5.31		
Magnesia		0.16		
Lime		trace		
Phosphoric acid	=	0.21	=	0.09 Phosphorus.
Silicic acid		6.76		
Quartz		12.78		
Water		9.21		
		100.00		

100 Iron contain 0.195 Phosphorus.

No. 19. Whorell Bank.

Two pieces of a fine brown porous amorphous ore of various shades, between yellowish and dark-brown; some portions showing a slight pitchy lustre; the greater part is dull. Has a strong argillaceous odor when breathed upon.

The analysis of an average sample gave:

Ferric oxide	=	69.71	=	48.80 Metallic Iron.
Manganic oxide		0.46		
Cobaltic oxide		trace		
Alumina		3.37		
Magnesia		0.08		
Lime		trace		
Phosphoric acid	=	0.97	=	0.43 Phosphorus.
Silicic acid		3.51		
Quartz		9.60		
Water		12.30		
		100.00		

100 Iron contain 0.87 Phosphorus.

No. 21. Wrye Bank.

Five specimens received. The ore is amorphous, porous, and scoriaceous. Some of the cavities are lined with a thin coating of fibrous ore. The more compact pieces contain a large admixture of rounded quartz grains.

An analysis of an average sample gave:

Ferric oxide	=	77.00	=	53.90 Metallic Iron.
Manganic oxide		0.36		
Cobaltic oxide		trace		
Alumina		2.15		
Magnesia		0.14		
Lime		0.15		
Phosphoric acid		0.19	=	0.08 Phosphorus.
Silicic acid		2.60		
Quartz		5.53		
Water		11.88		
		100.00		

100 Iron contain 0.15 Phosphorus.

No. 24. Dry Hollow Bank.

Amongst the eight specimens received for examination was one of a beautiful variety of fibrous limonite; the fibres are of about one inch in length, also divergent and radiating; color dark brown, lustre silky; the other ores were both compact and porous amorphous brown limonites, some with the cavities lined with fibrous ore, others having them filled with ochreous clayish ores. Some of the pieces give a strong argillaceous odor, when breathed upon.

a. Pure Fibrous Limonite.

Ferric oxide =	83.13 =	58.19 Metallic Iron.
Manganic oxide =	0.15	
Alumina =	0.74	
Magnesia	0.09	
Lime	trace	
Phosphoric acid	0.50 =	0.22 Phosphorus
Silicic acid	2.47	
Water	12.92	
	100.00	

100 Iron contain 0.37 Phosphorus.

b. Average of the eight Specimens.

Ferric oxide =	75.90 =	53.13 Metallic Iron.
Manganic oxide =	0.16	
Cobaltic oxide =	trace	
Alumina =	2.44	
Magnesia	0.20	
Lime	trace.	
Phosphoric acid	0.54 =	0.24 Phosphorus.
Silicic acid	2.74	
Quartz =	7.84	
Water	10.18	
	100.00	

100 Iron contain 0.45 Phosphorus.

No. 24. *b.* RED BANK OF DRY HOLLOW.

An examination of six specimens, showed the general character of the ore to be amorphous, of a dark brown color, and compact; some pieces have cavities lined with yellowish brown and dark brown fibrous limonite; others have rounded quartz grains disseminated through the mass. A portion of the ores has lost part of the water of hydration. The cavities and fractures are frequently coated or filled with a brownish red ochreous ore.

An average sample of the whole contained:

Ferric oxide =	80.34 =	56.24 Metallic Iron.
Manganic oxide	0.52	

Cobaltic oxide		trace		
Alumina		1.66		
Magnesia		0.13		
Lime		trace		
Phosphoric acid		0.49	=	0.215 Phosphorus.
Silicic acid		3.18		
Quartz		2.63		
Water		11.05		
		100.00		

100 Iron contain 0.38 Phosphorus.

No. 27. KERR AND BREDIN BANK.

The three specimens received show the ore to be mostly amorphous and compact, and of various shades of brown, also earthy; some parts are porous and the cavities lined with fibrous limonite, sometimes in botryoidal forms. On being breathed upon, developes a strong argillaceous odor.

The average of the samples contained :

Ferric oxide	=	70.67	=	49.47 Metallic Iron.
Manganic oxide		0.36		
Cobaltic oxide		trace		
Alumina		3.91		
Magnesia		0.26		
Lime		trace		
Phosphoric acid	=	0.19	=	0.08 Phosphorus.
Silicic acid		5.48		
Quartz		6.80		
Water		12.33		
		100.00		

100 Iron contain 0.16 Phosphorus.

No. 28. HOSTLER BANK.

One specimen of so-called "Pipe Ore." Amorphous, compact and earthy, brown to yellowish brown. Porous. Stalactitic. Coated with yellowish and reddish ochreous ore.

The analysis gave :

Ferric oxide	=	78.58	=	55.01 Metallic Iron.
Manganic oxide		0.08		
Alumina		0.88		
Magnesia		0.54		
Lime		0.30		
Phosphoric acid		0.36	=	0.158 Phosphorus.

Silicic acid		4.25		
Quartz	=	2.60		
Water	=	12.41		
		100.00		

100 Iron contain 0.28 Phosphorus.

No. 29. PENNSYLVANIA BANK.

a. Two samples received for examination.

Amorphous brown compact ore mixed with ochreous yellowish or reddish ore ; Porous, some of the cavities lined with a very fine coating of fibrous ore.

b. So-called Pipe ore.

Amorphous porous ore, in columnar masses, the cavities filled with ferruginous clay.

c. Quartz grains, cemented by brown amorphous limonite, and disseminated through it, patches of hydrous manganic oxide and perhaps of psilomelane.

a. Average of two Samples.

Ferric oxide	=	81.55	=	57.10 Metallic Iron.
Manganic oxide		0.10		
Cobaltic oxide		trace		
Alumina		1.49		
Magnesia		0.47		
Lime		trace		
Phosphoric acid		0.16	=	0.07 Phosphorus.
Silicic acid		2.98		
Quartz		1.55		
Water		11.70		
		100.00		

100 Iron contain 0.12 Phosphorus.

b. Pipe Ore.

Ferric oxide	=	83.74	=	58.62 Metallic Iron.
Manganic oxide	=	0.31		
Cobaltic oxide		trace		
Alumina		0.33		
Magnesia		0.34		
Lime		trace		
Phosphoric acid		0.14	=	0.06 Phosphorus.
Silicic acid		2.57		
Quartz		0.44		
Water		12.13		
		100.00		

100 Iron contain 0.10 Phosphorus.

c. Sandrock.

Ferric oxide	=	43.65	=	30.56 Metallic Iron.
Manganic oxide Cobaltic oxide		1.55		
Alumina		2.43		
Magnesia		1.64		
Lime		0.12		
Phosphoric acid		0.27	=	0.12 Phosphorus.
Silicic acid		5.19		
Quartz		36.52		
Water		8.63		
		100.00		

100 Iron contain 0.39 Phosphorus.

OLD CUT NORTH OF GATESBURG. *

A peculiar looking amorphous ore, of a brown and yellowish-brown color, uneven to subconchoidal fracture, dull or of slight waxy lustre, inclining to resinous. It has a strong argillaceous odor when breathed upon.

The composition of the one specimen, which I received for examination, was found to be :

Ferric oxide	=	71.63	=	50.14 Metallic Iron.
Manganic oxide Cobaltic oxide	=	0.53		
Alumina		4.63		
Magnesia		0.37		
Lime		trace		
Phosphoric acid	=	1.67	=	0.73 Phosphorus.
Silicic acid		3.69		
Quartz		4.64		
Water		12.84		
		100.00		

100 Iron contain 1.43 Phosphorus.

The amount of metallic iron in the calcined ores is as follows :

No. 1.	East Pennington Bank	51.49	per cent.
" 2.	West Pennington Bank	57.07	"
" 6.	Rumbarger Bank	59.08	"
" 11.	Lytle Bank	65.30	"
" 14.	Bull Bank—*a*, fibrous ore	66.25	"
" "	" " —*b*, average	59.41	"

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*Mr. Platt's Station 568.

No. 15.	Pond Bank, No. 1	63.14	per cent.
" 16.	Red Bank, No. 1	50.46	"
" 19.	Whorell Bank	55.64	"
" 21.	Rye Bank	61.17	"
" 24.	Dry Hollow Bank—*a*, fibrous ore	66.82	"
" "	" " " —*b*, average	59.15	"
" 24*b*.	Red Bank of Dry Hollow	63.23	"
" 27.	Kerr and Bredin Bank	56.43	"
" 28.	Hostler Bank	62.80	"
" 29.	Pennsylvania Bank—*a*, average	64.67	"
" "	" " —*b*, pipe ore	66.71	"
" "	" " —*c*, sandrock	33.44	"
Ore from Old Cut N. of Gatesburg		57.52	"

All these ores were examined for Sulphur and Sulphuric acid, but not a single one gave a decided reaction for either. They were also examined for Titanium, Chromium, Vanadium, and other metals, but with negative results.

Their only constituent, which has an injurious effect upon the quality of the iron, produced from the same, is phosphoric acid; most of them, however, contain it in too small a quantity to be of much harm. Only two of the samples contain it in a larger proportion.

For better comparison, I will arrange the amounts of Phosphorus which would be contained in 100 parts of iron, provided no loss of either would be sustained:

Fibrous ore of Bull Bank	0.06	Phosphorus.
Pipe ore of Pennsylvania Bank	0.10	"
Average ore of " "	0.12	"
Pond Bank, No. 1	0.127	"
Wrye Bank	0.15	"
Kerr and Bredin Bank	0.16	"
Red Bank No. 1	0.195	"
N. E. or Upper Pennington Bank	0.197	"
Average of Bull Bank	0.20	"
Lytle Bank	0.278	"
Hostler Bank	0.28	"
Rumbarger Bank	0.30	"
S. W. or Lower Pennington Bank	0.32	"
Fibrous ore of Dry Hollow Bank	0.37	"
Red Bank of Dry Hollow	0.38	"
Sandrock of Pennsylvania Bank	0.39	"
Dry Hollow Bank	0.45	"
Whorell Bank	0.87	"
Old cut N. of Gatesburg	1.43	"

Of all the ores submitted for examination only two appeared to be in a sufficient state of purity to throw light upon their constitution, as they were crystalline, and free from visible impurities. For this reason they were examined separately.

Taking into consideration only their principal constituents, viz : Ferric oxide, Silicic acid and water, the question arises, in which form the silicic acid is present, as it is undoubtedly in chemical combination with the ferric oxide and *not* in the form of a mechanical admixture of sand. If pieces of these fibrous limonites are placed into strong chlorhydric acid, all the ferric oxide will be extracted, and the silicic acid will remain in the shape of the original pieces, of a snow-white color and fibrous structure. The only hydrous ferric silicates, which are known, are Anthosiderite and Degeroeite. The former is a crystalized mineral, which has a composition, represented by the formula $2Fe_2O_3, 9SiO_2+2H_2O$. It is very probable that, although observed in its pure state only at one locality, it occurs frequently as an admixture with other iron ores.—If we calculate for the 3.98 per cent. of silicic acid in the fibrous mineral from Bull Mine, the requisite quantities of ferric oxide and water, we find 2.36 per cent. of ferric oxide and 0.26 per cent. of water, making an admixture of 6.60 per cent. of anthosiderite. The atomic ratio between the remaining 79.12 per cent. of ferric oxide and 13.64 per cent. of water is 1 : 1.53 or very near 2 : 3, showing the hydrous ferric oxide to be limonite $= 2\ Fe_2\ O_3,\ 3\ H_2\ O$.

If in the same manner we examine into the composition of the fibrous mineral from the Dry Hollow, the 2.47 silicic acid require 1.46 per cent. ferric oxide and 0.17 water, giving an admixture of 4.10 per cent. of anthosiderite.—The atomic ratio between the remaining 81.67 per cent of ferric oxide and 12.75 per cent. of water is 1: 1.4, which also shows the ferric hydrate to be limonite, which, however, has already lost a small part of its water.

The above analyses show besides the mechanically admixed rounded grains of sand, which I distinguish as "quartz," a considerable quantity of silicic acid, which is in chemical combination, probably as a hydrous ferric oxide. But as it is impossible to say what the true character of this mineral may be, whether anthosiderite, or degeroeite a silicate of the composition $Fe_2\ O_3,\ 2SiO_2+3H_2O$ or a species not yet known in its pure state, suffice it to say that all these ores are mechanical mixtures of limonite with hydrous ferric silicate and minute quantities of hydrous ferric phosphate, perhaps dufrenite or cacoxenite; some of the ores contain besides these, small quantities of manganese ores, mostly the so-called "bog-manganese" or wad, but also pyrolusite and psilomelane.

It is a very remarkable fact that, although these iron ores are to a great extent at least, the result of the decomposition of limestones and by them precipitated, that almost the entire amount of lime has been washed out of them and only traces are remaining ; of the second constituent of the limestones, the magnesia, a somewhat larger quantity is left behind, owing undoubtedly to the lesser solubility of its carbonate in carbonic acid water.

Of the limestones only a few typical varieties have been more fully investigated, especially those from the Hostler and Pennsylvania Banks.

Limestone at head of Hostler Bank.

It has a fine crystalline granular structure and is mottled, whitish and grey ; the surface is coated with ochreous argillaceous iron ore.

A pure specimen from which the iron had been carefully removed, contained :

Carbonate of Iron	=	0.80	=	0.39 Metallic iron.
" " Manganese	=	0.19	=	
" " Magnesia	=	35.19	=	16.76 Magnesia.
" " Lime	=	59.44	=	33.28 Lime.
Quartz and Silicic Acid		3.84		
Alumina		0.54		
		100.00		

The atomic ratio between Magnesia and Lime is 1: 1.4, which is the composition of some of the "pearlspar" varieties of dolomite.

Limestone in Hostler Bank.

It lies four feet thick over 33 feet of pipeore. It has an ash-grey color and a very fine grain, which is hardly perceptible to the naked eye ; very friable. Its composition was found to be :

Carbonate of Iron	=	0.50	=	0.24 Metallic Iron.
" " Manganese	=	0.24		
" " Magnesia	=	42.52	=	20.25 Magnesia.
" " Lime	=	51.82	=	29.02 Lime.
Quartz and Silicic Acid		4.33		
Alumina		0.42		
Water		0.17		
		100.00		

The atomic ratio between Magnesia and Lime is 1: 1, which shows it to be a true dolomite.

Upper Limestone from Pennsylvania Bank.

Dark grey compact, slightly crystalline

The analysis gave the following results :

Carbonate of Iron	=	1.31	=	0.63 Metallic Iron.
" " Manganese	=	0.18		
" " Magnesia		3.98	=	1.90 Magnesia.
" " Lime		72.67	=	40.69 Lime.
Quartz and Silicic Acid		18.05		
Alumina		3.81		
		100.00		

The atomic ratio between magnesia and lime is 1 : 15.

LIMESTONE IN THE PENNSYLVANIA BANK.

Pale ash grey, very finely crystalline, rough to the touch like rotten stone, very friable and easily falling to powder.

Its composition was found to be:

Carbonate of Iron	=	0.45	=	0.22 Metallic Iron.
" " Manganese	=	0.06		
" " Magnesia		42.39	=	20.19 Magnesia.
" " Lime		51.25	=	28.70 Lime.
Quartz and Silicic Acid		5.03		
Alumina		0.83		
		100.00		

The atomic ratio between Magnesia and Lime=1 : 1, shows it to be a true dolomite.

ANOTHER VARIETY OF LIMESTONE IN THE PENNSYLVANIA BANK.

Yellowish grey, soft, rotten, feels rough to the touch, sandy; crystalline; has a laminated structure. Its analysis gave:

Carbonate of Iron	=	1.18	=	0.57 Metallic Iron.
" " Manganese		trace		
" " Magnesia		35.51	=	16.91
" " Lime		45.73	=	25.61
Quartz and Silicic Acid		15.83		
Alumina		1.75		
		100.00		

The atomic ratio between Magnesia and Lime=1 : 1.08 proves it also to be a true dolomite.

It is remarkable that the limestones and dolomites, of which I give the analyses, contain almost the entire amount of silicic acid as quartz, only a small quantity is present as soluble silicic acid and in combination with alumina. If the limestones and dolomites are dissolved in acid, the quartz remains often as a scoriaceous mass or in irregular sandy but not rounded or water-worn grains; sometimes it forms large coherent slaty masses in the limestone, frequently filled with minute cavities, previously occupied by rhombohedral crystals of dolomite. Similar pieces found in the Pennsylvania Bank are white, like porcelain and show the same cavities of rhombohedral crystals. Other varieties of limestone in the Pennsylvania Bank have a still greater admixture of quartz and are a real calciferous sand rock.*

UNIVERSITY OF PENNSYLVANIA, January 23d, 1874.

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* These analyses summed up about 100, most of them a little above, one or two a little below, but all within the limits of unavoidable error; for better comparison I thought it advisable to calculate them for 100.00, from the actual result obtained. (F. A. Genth.)

ANALYSES* OF PENNSYLVANIA PIPE, AND PENNINGTON ORE.

3, DEVONSHIRE TERRACE, KENSINGTON, LONDON, W.,
January 5*th*, 1871.

DEAR SIR:—Herewith I beg to forward you the results of my analysis of the two samples of ore, marked, respectively, "Pipe Ore" and "Pennington Bank."

The whole of the samples were intimately pulverized together in each case; they contain

	PIPE ORE.	PENNINGTON BANK.
Silica	10.84	5.42
Peroxide of Iron	73.18	79.05
Protoxide of Iron	.75	
Aluminia	2.51	1.29
Oxide of Manganese	traces.	.11
Carbonate of Lime	.20	
Carbonate of Magnesia	1.20	Magnesia. .11
Phosphoric Acid	.17	.04
Combined Water	9.09	10.57
Moisture	1.81	3.55
Sulphur	.05	
	99.80	100.14
Metallic Iron	51.81	55.34
" " exclusive of Water	58.25	64.35

Both these samples are rich iron ores, sample "Pennington Bank" being nearly pure brown hematite. The pipe ore is a harder ore than "Pennington Bank" ore.

I consider both samples of ore adapted for the manufacture of Bessemer Pig.

Believe me to remain, yours, very faithfully,

EDWARD RILEY, F. C. S.,
Metallurgist, Analytical and Consulting Chemist.

ANALYSIS OF "PIPE ORE," "KERR & BREDIN" AND PENNINGTON BANK ORES, BY CH. ALDENDORF, SUB-DIRECTOR OF THE GEORGE-MARIEN HUTTE HIGH FURNACES, MARCH 9, 1872.

	PIPE ORE.	KERR & BREDIN.	PENNINGTON.
Water	11.190	10.540	12.340
Insoluble Residue, $\left.\begin{matrix} Si\,O^2 \\ Al^2O^3 \end{matrix}\right\}$	5.120	13.400	5.450
Oxide of Iron, F^2O^3	82.050	73.560	79.450

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* These analyses by an English chemist of well known reputation, especially entrusted by Mr. Bessemer with his numerous and important analyses, is here added for comparison.

		PIPE ORE.	KERR & BREDIN.	PENNINGTON.
Alumina,	Al^2O^3.....	1.650	2.840	3.096
Oxide Manganese,	Mn^2O^3....	0.270	0.190	0.440
Chalk,	CaO.......	0.370	0.460	0.440
Magnesia,	MgO......	trace.	trace.	trace.
Phos. Acid,	$P.O^5$......	0.080	0.280	0.064
Sulphuric Acid,	$S.O.^3$.....	trace.	trace.	trace.
		100.730	101.270	101.280
Per cent. Metallic Iron......		57.435	51.492	55.615
Phosphorus in 100 Iron......		0.061	0.238	0.053
Per ct. Iron. excluding Water,		64.150	56.075	62.540

"The Pipe and Pennington Ores if melted together would make a very superior Bessemer Iron. The Kerr & Bredin *alone* an inferior Bessemer Iron. A separate analysis, however, of Kerr & Bredin shows that its Phosphorus is concentrated in the Clay thereto attached, and it may be that this Ore may be made available for Bessemer Pig, by proper treatment before smelting."

ANALYSIS OF PENNSYLVANIA FURNACE LIMESTONE BY OTTO WUTH, CHEMIST, PITTSBURGH, PA.

From Quarry near the Furnace—a grey crystaline Stone :

Silicic Acid..................................	5.08
Alumina..	1.34
Carbonate of Iron..................................	.69
" " Lime..................................	91.53
" " Magnesia..............................	1.31
Sulphate of Lime..................................	trace.
Organic Matter....................................	.05

From Ore Bank Rail Road Cut — a partly crystalline drab-colored stone :

Silicic Acid..	4.93
Alumina..	.24
Carbonate of Iron..................................	.87
" " Lime..................................	84.66
" " Magnesia..............................	8.98
Sulphate of Lime..................................	.11
Organic Matter....................................	.21

Gray Crystalline Stone, south side of road from Half Moon Run to Hostler Bank, near the Half Moon Run.

Silicic Acid	2.71
Alumina	.11
Carbonate of Iron	1.80
" " Lime	83.91
" " Magnesia	11.14
Sulphate of Lime	.12
Organic Matter	.21

Smooth Grey Stone from north side of road near the foregoing:

Silicic Acid	6.87
Alumina	1.35
Carbonate of Iron	.75
" " Lime	86.42
" " Magnesia	4.24
Sulphate of Lime	.21
Organic Matter	.16

MINING METHODS.

It will be seen from the above descriptions, that mining operations have been mostly carried on in this region in an irregular and primitive style. I requested Mr. John W. Harden to give me the benefit of his great and varied experience as a mining engineer and superintendent, both in the English and in the American collieries and iron mines, in stating what ought to be the most economical mode of entering on and exhausting the Nittany Valley limestone deposits. His recent success in increasing the export of limonite from Pinegrove Furnace banks south of Carlisle, by a judicious application of a system of regular approaches, justifies me in placing a high value on any practical suggestions he has to offer respecting similar deposits.

He therefore visited the Pennington, Dry Hollow, Kerr & Bredin, Pennsylvania Furnace, and other Banks above described; and the following extracts from his report will show that there is but one conclusion to arrive at, and that a very simple one ; viz., that the system to be almost universally adopted is that by open-cuts, approached from the direction of the railway, at the lowest possible levels, and worked to the right and left, in advancing slopes, one above the other ; that the deep rich-ores should be worked at the same time with the upper wash-ores, or not greatly in arrear of them, so that the wash-ore thus won may pay the expenses of uncovering the richer lower ores; and that where surface water is scarce, bore-holes should be sunk to serve the double purpose of exploration and water supply.

Whether additional and larger furnaces be erected in the Valley, or whether the ores be sent by rail to the Iron Works in Eastern and

Western Pennsylvania, in both contingencies an exploitation of ore must be provided for, amounting annually to many hundred thousand tons per annum.

The largest mining operation in the Valley being that of the Pennsylvania Furnace, Mr. Harden takes the account book of the works at that point for a practical basis of calculation of the cost of exploitation. It is evident that mining conditions through the Valley are very similar. No system of between-rock mining will be required for many years. But exploring drifts and shafts will be necessary, and under-cutting where the clays are destitute of ore and too thick to remove. Most of the work however must be done in open cuts of great extent, with simple machinery for obtaining water and washing the entire mass of ore-ground to the very bottom, or to the deep rock-ores, which can be quarried and used without washing. In many cases the rock-ore, and in some cases the clay-ore, can be followed downward between solid masses of limestone rock ; but this must be done in connection with the open-cuts.

At the Pennington Banks there appear to be from 50 to 80 feet of wash-ore and clays overlying from 8 to 16 feet of rock-ore.

At the Dry Hollow Banks there is a stripping at the surface from 5 to 15 feet deep containing but little ore; then wash-ore with sands and sandy clays to a depth of 20 or 30 feet before reaching rock-ore.

At the Hostler Banks a top stripping of 5 feet or more, covers 50 to 60 feet of wash-ore in clay, under which lie the pipe-ores, which are reported as having been in one place over 40 feet deep ; limestone layers covering and dividing the mass. The miner who sunk the last shaft informed Mr. Harden that it went down 60 feet through wash-ore, 5 feet through solid limestone, and 7 feet in pipe-ore on one side of it, and wash-ore on the other side ; water stopping further sinking.

At the Pennsylvania Furnace Banks, the entire mass from the surface to the floor of the quarry is wash-ore mixed with clay and sand. The whole of this mass has been washed. "In one place a 13 feet face of excavation gave 3 to 4 feet of surface soil and sienna-colored sandy-wash, the remainder below it being a sandy, whitish ochre, and sienna-colored clay, streaked and marbled with red and brown, and some, not large lumps of ore. Scattered through the whole, in considerable quantity in some places, are small pieces of quartz which are picked out after the ore has passed over the trays. In another part of the diggings this quartz, from the size of shot to lumps 3 or 4 inches thick, is scattered through the mass.* Some masses of this quartz, of one or two cubic feet in size, lie about the quarry.

"In a deeper part of the diggings where the face of iron and work measures 45 or 50 feet, in two heights of 15 and 30 to 35 feet, now being moved to the inclined plane for washing, the face is made up of sand and various colored clays holding ore, all of which is washed. Limestone appears at the bottom and pipe-ore has been found underneath it."

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* Mr. Harden gives an analysis of this quartz : Water, 0.50, Silica, 96.00, Iron and alumina, 1.76, undetermined, 1.68.

Mr. Harden advises that the stripping of wash-ore be not carried on far in advance of the lifting of the rock and pipe-ore at the bottom; because, even where the farming interest does not interfere, such a plan "disturbs the equal distribution of dead work" and prevents the rejection of those parts of the stripping which do not pay well for washing. Ample room ought to be got early for lifting the entire mass of rich bottom ores.

"With a good roomy open cutting the mass of wash ore should cost no more to move than so much ordinary excavation." "The ore-earth is loaded into cars carrying 29½ cubic feet, led by horses to the foot of the incline, 300 to 500 feet, whence it is lifted 37 feet on a grade of 14°, to a level with the washers, by a 12 inch cylinder steam engine, 2 foot stroke, and pair of 8 foot drums. The car load is again dragged 150 feet and dumped into the washing troughs, in which revolve three Archimedian screw-propeller shafts 20, 26, and 26 feet long respectively. The shafts are of decagonial timber, 15 inches in diameter on the facets of which are screwed cast iron blades. The ore travels 72 feet, and is dropped into two classifying screens, the sand and mud being floated off to the settling dam. The screens have ¼ inch and $\frac{1}{12}$ inch meshes. The ore falls on sheet iron trays where the quartz is picked out. The washers are driven by a 16 inch cylinder engine, 54 inch stroke; the steam being generated in two double flue boilers 30 feet long and 40 inches in diameter. The water arrives by an aqueduct 2000 feet long mounted on tressels arranged along the top of the hill. It is fed by a pipe of 12 inch diameter laid up the hill-side to a vertical height of 110 feet above a double Worthington pump with 20 inch steam and 15 inch water cylenders; the fall of reservoir is 1 foot in 250. The steam boilers for the pump are also 30 feet long by 40 inches diameter, driving also a Blake stone-crusher, used for the flux.

The digging of the ore is said to be done by contract at half the price of ordinary earth.

Six cubic yards of earth has been found to produce an average of one ton of washed ore, the diggers being paid 16 cents per car-load of 29.58 cubic feet = 23.67 of solid earth. A cubic yard will therefore cost 18¼ cents and a ton of ore $1.09. The ore delivered at the furnace costing $2, there remains 91 cents for leading, raising, washing, picking and delivery.

But the great economy of this operation can be duly realized only by remembering that the earth washed and ore utilized is that which under any other circumstances would be dumped on one side as "spoil," and as such chargeable against the lower and better ore. "Seeing also that in so utilizing this (otherwise) refuse just so much dead charge is removed, we are led to anticipate a less costly production of the ore which follows it; and we have ground for contemplating equally favorable results at other banks, the same course being pursued."

The Furnace stands under the high bank of Spruce Creek, with its village occupying the upper slopes on both sides of the Creek, and the farms stretching south and east to the foot of the mountain. It is a stack 43 feet high, 9½ feet across the boshes, 48 inch tunnel, slope of boshes 68°, hearth 5½ feet high, 48 inches wide at top and 30 inches at the bottom, with two cold air tuyeres, fed from blowing-tubs 6.4 long, driven by a 16 inch cylinder engine, 4½ feet stroke. A Cameron blast 22 inch steam cylinder and 6 × 5 feet blowing-tub is held in reserve. Steam is generated in three 30 feet cylinders, 42 inches in diameter, fed with Creek water by a No. 4 Cameron steam pump, with a No. 8 Earl steam pump in reserve. Another steam-engine drives three lathes.

The uniform yield of the furnace has been 100 tons per week. It is now changed to hotblast, by the recent erection of a Pleyer oven 17×5×2½ feet, with six tiers of pipes, in a building 17 × 12.

THE FOSSIL ORE BELT.

On the north-west flank of the Bald Eagle Mountain the Medina Red Sand-stone and the Clinton Red Shales and Marls, all standing vertical at the out-crop, (see figs. 1, 2, 3, 4,) bring up to the surface the Upper Soft and Lower Hard Fossil Ore Beds, long and extensively worked at Frankstown in Blair County, 15 miles south of Tyrone City.

One or other of these out-crops may be noticed at three points marked on the west flank of the Bald Eagle Mountain in the Large Topographical Map accompanying this report.

On a separate and smaller Map of the same Mountain, continued to the south of Tyrone under the local name of Brush Mountain, both out-crops may be seen in the same relative positions.

On the sheet containing this smaller Map are three geological cross sections, two of which show the vertical attitude of the fossil ore-beds at Tyrone City Gap, and the third their more inclined attitude at Dysarts Mine, at the south limit of Lyon, Shorb & Co.'s lands, four miles south of Tyrone City Gap. By the time the beds reach Frankstown they get to be nearly horisontal. Beyond Hollidaysburg they become vertical again, owing to the Morrison's Cove fault (which exactly simulates the Bellefonte fault), and again they die away to the horisontal on Dunnings Creek. At Bedford they are again vertical; and so they alternately stand and fall through Virginia and Tennessee.

In the other direction from Tyrone City, north-eastward, the vertical attitude of the fossil ore-beds is pretty well maintained for forty miles; past Bellefonte, Lock Haven and Wilkesbarre, to Muncy, where they fold almost horisontally around the east end of the Bald Eagle (Muncy) Mountain.

Wherever the out-crops of the fossil ore-beds of No. V. have been examined, along their out-crops to the north-east of the Tyrone neighborhood, they have been found too thin to work; at least, for cold blast charcoal furnace use, in the presence of the magnificent deposits of brown hematite in the Lower Silurian Limestones (No. II).

But from the neighborhood of Tyrone City Gap southward, past Frankstown, Holidaysburg and Bedford, they have paid well for mining, and continue to furnish an apparently inexhaustible fund of 30 per cent. to 40 per cent. ore to the large coke-furnaces of Blair and Cambria Counties.

By comparing my larger topographical Map with Mr. Lowrie's Land Map it will be seen that the out-crops of Fossil Ore on Lyon, Shorb & Co.'s lands range in an unbroken line from the Abner Webb tract to the Shippen tract, a distance of ten and a half (10½) miles, and always in an attitude nearly or quite vertical; falling off at the south end to 60° W. N.W.

The geological order of the beds at Frankstown, where they are extensively mined, is by careful measurement as follows:

Red Shale of No. V. (Clinton Group.)
e. Soft fossil ore, small single bed, 3 to 8 inches.
Red Shale, 100 feet.
d. Soft fossil ore-bed.
Yellow ochre, 10 feet. In all 25 to 40 inches.
c. Soft fossil double ore-bed.
Red shales and some thin sand stones, 400 feet.
Chocolate slates, 20 feet.
b. Frankstown main soft ore-bed, 14 to 16 inches.
Grey and dove colored slates, 17 feet.
Red sand stones and shales, 155 feet.
a. Hard fossil ore-bed, about 10 feet.
Red and grey sand stones of IV, to the crest of the Mountain, say 700 feet.

a. HARD FOSSIL ORE BED.

This is a layer of sand charged with peroxide of iron and full of minute fossil shells and encrinal discs the calcareous parts of which are dissolved away. It forms a bed of ore yielding by analysis about 30 per cent. of iron; and in the furnace 3¼ to 3½ tons of it make a ton of metal, always cold-short, and therefore chiefly valuable when mixed in proper proportions with other ores.

Prof. Persifor Frazer's analysis of specimens taken from the middle bench in Dysart's Mine recently opened (see smaller Map), made for me in his laboratory in the University of Pennsylvania, is as follows:

Specific gravity: 3 26.

Sesquioxide of iron	38.48	Metallic iron 30.34
Protoxide of iron	4.37	
Silica	37.99	
Alumina	9.56	
Lime	1.08	

Magnesia	a trace.
Alkalies	2.54
Phosphoric Acid	1.48
Sulphur	0.05 (trace.)
Loss by ignition	4.50
Total	100.00

At Howard Furnace the ore was analysed, &c., some years ago and found to contain 28 per cent. of iron.

The bed was here found standing at 80° towards the N. N. W. and only 22 inches thick.

In the end of the Mountain south of Tyrone City this bed has been recently opened at a height of 260 feet (by barometer) above the Juniata River, the slope of the surface being 40°, and the pitch of the bed at the out-crop 60° into the mountain (S. E). But this is due to the creep of the out-crop down hill. The body of the bed stands vertical.

There is 6½ feet of rock-ore between overlying sandy shales and underlying foot shales; only the upper 22 inches of the bed in six plies is here workable.

At Dysart's, 4 miles south of Tyrone city, a tunnel 20 feet long, 575 feet (bar.) above the level of the Juniata, strikes the bed pitching 50° to 60° (at the two headings, right and left)* towards the N. 50° W. About six feet of ore is here mined and sent to Pittsburgh, *via.* Tipton Station on the Pennsylvania Railroad at the foot of the mountain opposite the mine.

At the heading in Oct. 1873 was seen the following order of layers:

Fossil ore, at mouth of tunnel in soft rotten shale		6 inches.
Rock in tunnel	16 feet.	
Hard lean fossil ore	1 "	5 inches.
Hard fossil ore	2 "	10 "
Clay parting		2 "
Hard fossil ore	2 "	0 "

Soft shale floor rotted into compact mud, the water bearing stratum.

In October 1873 a Pittsburgh furnace was doing good work mixing ¼ of this Tipton (Dysart) ore with ¾ of a very pure ore, deficient in silica and alumina, which deficiency the hard fossil ore supplied; and that, without any marked prejudice to the run of the furnace as to quantity, although two-thirds of the Tipton ore went below 40 per cent. and one-third below 20 per cent. of iron; the Tipton ore making good cinder, and thus relieving a part of the pure ore from that duty. The quality of the pig-metal produced after the mixture was adopted remained unchanged.

This aspect of the future utility of this lowest deposit *a* of the fossil ore series of N. V. is important.

At Frankstown the bed sometimes reaches a thickness of ten feet.

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* Higher up, red sandstone at the surface dips 78°.

On the southeast flank of Tussey Mountain at R. H. Powell's mines, ten miles southeast of Frankstown, the same bed varies from 15 to 25 feet in thickness, and shows three well-marked benches, an upper and a lower of sandy rock ore, and a middle bench, 5 or 6 feet thick, of soft rich fossil ore, which is mined by the Cambria Iron Co. and transported in large quantities ninety (90) miles by railroad *via.* Huntingdon and Tyrone city across the Alleghany Mountain to the Company's furnaces at Johnstown in Cambria County, for mixing with coal-measure ores (mined back of the furnaces) and high grade ores from Lake Superior and Missouri.

This is another practical evidence of the importance of this deposit to the pig-metal make in America.

The bed is absolutely continuous and uninterrupted. Its outcrop can always be found at a well-defined elevation on the flank of the Upper Silurian Mountain, and about two-thirds of the distance from the base towards the summit. But the bed is very variable in thickness even in distances of a few hundred yards, and ought to be opened in many places along its run of nearly eleven miles through Lyon, Shorb & Company's lands, before any extensive mining plant is made.

Its solid contents *above water level* is very large. Southwest of the Tyrone gap it contains above water level from one to three million cubic yards of ore, according as its thickness varies from three to nine feet. Northeast of the gap, it contains one to two millions more, allowing for the probable general thinning of the bed in that direction; but as experience has taught us that sections of its outcrop are very likely to show an exceptionally great thickness, the estimate may be indefinitely increased.

Along the whole 10½ miles of outcrop it runs parallel to and within less than a mile of first-class railways, (the Pennsylvania Railway, and the Bald Eagle Valley Railway,) which offer facilities for distributing it to furnaces in northern, eastern, and western Pennsylvania. It is also exposed on both sides of the Tyrone Gap, on the line of the Pennsylvania Railroad, so that a main gangway a mile long can be driven in just high enough above grade to allow of shutes on a siding.

This bed in its descent beneath the surface and water level probably suffers no such change as that which the soft fossil ores (to be next described) suffer, and it can therefore be mined hereafter to an indefinite distance downwards by shafts and slopes. This fact adds many millions of tons of available ore to the estimate given above.

SOFT FOSSIL ORE BEDS.

About 40 inches of this ore may be looked for along its outcrop wherever the deposit *c*, *d*, is in good order. Sometimes its three beds are near enough to mine in one gallery. Oftentimes one or another of them is wanting. Often they lie ten, twelve or more feet asunder. The variations are frequent and rapid. Several hundred feet beneath the triple bed *c*, *d*, occurs at Frankstown bed *b*, so thick as to be called *there* the main bed. A hundred feet above the triple bed *c*, *d*, at Frankstown is still another layer a few inches thick.

It is important to note the order in which these deposits occur to the explorer descending the mountain side from the outcrop of the hard fossil ore, because it is very evident, that the occasional openings made along the range on one or other of the three principal soft fossil ore outcrops, viz. *b;—c, d;—e;*—are very misleading. The Bald Eagle Mountain was for many years condemned by geologists as destitute of *workable* fossil ore, because the number of beds was not known; no comparison of localities was made; no complete section down the mountain slope, at any one place. Since the different beds vary in thickness constantly and rapidly, and apparently under a law which may be rudely stated thus: *when one bed thickens it is at the expense of the others*, as if there was but a certain quantity of iron at command and sometimes one bed would get more than its share, and sometimes another,—it follows that the value of any tract on the mountain side can be determined only after a thorough trial of all three (five) outcrops of soft fossil ore has been made; and in no instance has this been done, in the range of 10½ miles upon the Lyon, Shorb & Co.'s lands, nor between them and Frankstown, nor east of them.

Every road decending the west face of the mountain exposes one or more of these outcrops; the highest (lowest geologically) being always 50 or 60 yards below the hard fossil outcrop, where the sandstones of the crest commence.

The red sandstones of the crest and first steep pitch of mountain side between the crest and the hard fossil outcrop, send a multitude of fragments down over the soft yellow and red shales forming the middle slope of the mountain, and under these the soft fossil outcrops lie concealed. The gentle foot-slopes of the mountain are occupied by limestones, marls and red shales.

One of the soft fossil beds has been opened 1,300 yards northeast of Tyrone city, as shown on the Brush Mountain map accompanying this report, at an elevation of 370 feet above Railroad grade. A limestone bed crops out 70 yards down the slope (above it geographically) at 320 feet above railroad grade. The ore-bed is opened by a tunnel and "is 18 inches thick," including some thin layers of ferriferous fossil limestone. It stands "vertical," or overturned slightly so as to dip into the mountain in a direction S. 48° E.

Nothing is known of the other beds.

Experience at Danville and Bloomsburg in Eastern Pennsylvania has proved that the soft fossil ore can be extensively mined when only 16 or 18 inches thick (on a general average of the workings) as may be seen by reference to the very important chapter written on this subject by Prof. H. D. Rogers at page 440 and onward in the first volume of the Final Report of the Geology of Pennsylvania. Experience at Frankstown has been similar. But at these localities the gentle dip has its bearing upon the economy of mining, and perhaps upon the question of depth to which the *softening of the fossil limestone into soft fossil ore* has gone. I say perhaps, because it was Mr. Rogers' fixed opinion that the fossil ore would not be found fit for mining operations along those runs of outcrop where the beds stood at a steep angle, or vertical. This opinion must be set aside, since the long horisontal gangways, at water level, at Bedford, have yielded the soft ore in a perfect condition at a depth of several hundred feet vertically beneath the outcrop.

It is safe therefore to expect, in the ten or eleven miles of ore-range to find one or more of the beds at other place, of workable thickness and in good condition, with an average breast above water level of from 200 to 400 feet. If only 18 inches of proper ore can be got from all five beds, along the whole 10½ miles, there exists practically 925,000 cubic yards of the ore above water level. If the average thicknesses mined at Frankstown extend to Tyrone city, then there exists in the four miles of mountain side along the Pennsylvania Railway alone, and above water level alone, 42 to 64 inches × 7,040 × 100 = 2,464,000 to 3,731,200, = say three millions of cubic yards of ore.*

It is not to be expected that all the beds can be mined at any one place; but a million of tons of good merchantable soft fossil ore to be won from the southwest division of the Lyon, Shorb & Co.'s lands, *above water level* cannot be an unreasonable estimate.

This ore is greatly esteemed and extensively used by all the furnaces of Pennsylvania which can get it, as an enriching flux for leaner ironstones, and as a fusable mixture for refractory highgrade magnetites. At Frankstown and elsewhere it has furnished the greater part of the burden; and at other furnaces it is mixed in large proportions with brown hematites. It always holds lime in the condition of undissolved fossil shells, and works kindly with the sandy rock fossil (*a*) of the same (Upper Silurian) formation.

THE BROWN HEMATITES OF VI.

I shall say but little of these, and with much hesitation.

There runs a chain of low hills along the foot of the Bald Eagle (Brush) Mountain, the southeast side of which is limestone, the crest sandstone, and the northwest side black slate. The sandstone (VII) marks the top of the Silurian System, and the bottom of the Devonian System. The limestone (VI) corresponds in Pennsylvania to the Lower Helderburg and Niagara Falls limestone group of New York State and Canada. It is everywhere ferriferous, and at certain points yields astonishing quantities of excellent brown hematite ore. Such a point is Baker's Mine between Tyrone city and Altoona on the Pennsylvania Railroad. From this and another open cut a mile or so distant in the direction of Tyrone hundreds of thousands of tons of first-class ore have been mined during the last thirty years with no signs of exhaustion. Similar deposits may exist along the outcrop of VI and VII in the Valley of the Bald Eagle Creek on the Lyon, Shorb and Co.'s lands.

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* Mr. Rogers' formula of 50,000 tons of ore from each running mile of outcrop was based upon his then assumed maximum depth of no more than 30 yards for the soft ore in a stratum 18 inches thick, two tons of ore going to a cubic yard.

The black slates of VIII are the front edge and bottom formation of the lofty Devonian face or slope of the Alleghany Mountain capped with Coal Measures. Important beds of brown hematite are known to exist in this unexplored district. They belong to a system of limonite rocks largely developed and extensively mined where the same rocks descend, east of Tussey Mountain, beneath the Broad Top Coal Basin.

The Larry's Creek hard "fossil" ore of IX (Upper Devonian; not a true fossil ore, but a pisolite) also ranges through the hills and across the ravines descending from the Alleghany Mountain. But I believe it to be everywhere worthless, because it has been examined at a number of points back of Bedford, and back of Williamsport, and never has been found worth working.

COAL.

Finally the lowest beds of coal pass through the Western tracts on the summit of the Alleghany Mountains, 3000 feet more or less above tide level.

THE SITUATION.

No combination of advantages was ever offered for the growth of an inland city greater than that which has already secured for Tyrone City its exceptional prosperity. The map explains the situation. Built on a level plain, the delta of the Little Bald Eagle Creek, at a gap in the barrier of the Bald Eagle Mountain to which the trade of Western Pennsylvania converges, to follow the waters of the Juniata River to the seaboard, Tyrone City commands the gate of this inland commerce of Pennsylvania. Seven railroads here converge, viz: the Pennsylvania Central, with its Hollidaysburg branch from the Morrison's Cove and Bedford ore regions, and its Bell's Gap branch from the Coal Measures of Cambria County; the Bald Eagle Valley Railroad, with its Tyrone and Clearfield branch from the Osceola and Phillipsburg coal fields, and the Bellefonte and Horse Shoe Branch from the Moshannon coal field; and the Lewisburgh Centre County and Tyrone Railroad which passes the brown hematite mines of the Nittany Valley. Ore of every kind, and fuel from the anthracite as well as from the bituminous coal fields, here meet at a natural centre already adopted by the Railway system. The roar of railway trains through the gap literally never ceases, day nor night. A train from one direction or another passes Tyrone station on an average every three or four minutes.

The shops of the Pennsylvania Central are at Altoona 14 miles distant where the 1° ascent of the Alleghany Mountain commences. Large manufacturing establishments, therefore, will characterize the future of

Tyrone; and especially iron works. Two rivers of mountain-sandstone water meet at the gap. Ribs of limestone and hydraulic cement range through the first heights back of the town. An immense forest covers the heights beyond and spreads thence through the western counties. Nine hundred feet above tide, the place enjoys an admirable summer climate, while the cold of winter is not excessive. The valleys in front have been settled about a hundred years, and the population is ample for the supply of hands. The fertility of the limestone farms is famous. One extensive tannery already utilises the hemlock bark brought down by the railways descending the mountain, and the leather manufacture will have one of its centres here on the closing up of the connection of the Clearfield with the Bennett's Branch Railway.

A glance at the map of Pennsylvania will suffice to show the future importance of Tyrone as the terminus of a new through line of railroad already approaching completion. The Pennsylvania Railroad ascends the Alleghany Mountain from Pittsburgh by following the Kiskaminitas or Conemaugh river, through Westmoreland and Fayette counties, to its head in Cambria county. It then descends the front of the mountain to Altoona and Tyrone, and follows the Juniata river and the Susquehanna river to Harrisburg and the Seaboard.

Another railroad, virtually owned by the same great corporation, ascends the Alleghany river, and then its branches the Red Bank and Sandy, to a low divide in Jefferson and Clearfield counties, and so passes over to the head waters of Bennet's branch and the West branch of the Susquehanna river, which it descends to Harrisburg and the Seaboard. This more northern line is intended to relieve the middle or main line of all its slow and heavy freight.

The two lines are cross-joined by the Bald Eagle Valley railroad, between Tyrone and Lock Haven; and will be connected again and lower down by the Lewisburg, Centre County and Tyrone Railroad, as shown upon my map.

But an east and west *third* connection will be made between Tyrone and Reynoldsville, by extending the Tyrone and Clearfield Railroad (which is shown on the north edge of the map) a few miles to meet the Low Grade Slow Freight Line at Reynoldsville. When this is done, Tyrone will be the terminus of another main line connecting the Western country with Eastern Pennsylvania. By this road the superb coal field of Clearfield, Jefferson, Indiana, and Armstrong counties will have a direct outlet upon the Pennsylvania Central Railroad at Tyrone. This field has been, until now, entirely closed; and yet it is perhaps, on the whole, the largest and richest in the State, not excepting that of Westmoreland county. Some of its beds make excellent coke, as good as the Connellsville coke; one or two yield high gas coal; and the Ferriferous Limestone horison of iron ore, of the Lower Coal measure, spreads through it.

SCHEDULE OF JUNIATA LANDS HELD IN FEE SIMPLE BY LYON, SHORB & CO.

I. LANDS ATTACHED TO TYRONE FORGES.

DATE OF WARRANT.	ACTUAL CONTENTS.		NAME OF WARRANTEE.	LOCATION.	REMARKS.
	Acres.	*Perches.*			
17 June, 1806,	207	122	John Gloninger,	Blair County,	Forge buildings on it.
8 Sept., 1808,	20	148	John Gloninger,	"	Mill and Water Power on it.
1 Feb'y, 1794,	200		Frederick Lazarus,	"	Mountain Fossil ore on it.
8 Oct., 1784,	160		James Harris,	"	Adjoins Tyrone.
1 Aug., 1766,	110		Edward Shippen,	"	" "
15 May, 1804,	318		Elisha Davis,	"	" "
2 Sept., 1793,	402		John Smith,	"	Brush Mountain Fossil ore.
2 Sept., 1793,	280		Barney Carr,	"	" " "
8 Oct., 1784,	380		Alexander Hale,	"	Bald Eagle Valley land.
8 Oct., 1784,	200		David Ewing,	"	" " "
16 Aug., 1824,	208		George Anshutz,	"	Brush Mountain Fossil ore.
1 Feb'y, 1794,	270		Gill Robbins,	"	" " "
2 Sept., 1793,	390		William Harrison,	"	" " "
2 Sept., 1793,	170		Isaac Jones,	"	" " "
3 April, 1767,	205	71	Christopher Lewis,	"	Lands lying from 1 to 2 miles from Tyrone, growing up in second growth Timber, and capable of being developed into good farms, well watered and unsurpassed for grazing and grass growing.
9 Mar., 1767,	232	39	Augustine Neiser,	"	
29 Jan., 1794,	140		Thomas Hamilton,	"	
19 June, 1855,	242		J. R. Lowrie,	"	
14 June, 1855,	425		J. R. Lowrie,	"	
1 Dec., 1784,	313		James Craig,	"	
20 Oct., 1813,	205		Elisha Davis,	"	
20 Mar., 1794,	197		Whitson Birdsall,	"	
	403		George Anshutz,	"	
8 Oct., 1784,	108		Gavin Hamilton,	"	
15 Aug., 1828,	363		John Gloninger,	"	
21 Oct., 1813,	326		Martin Rahm,	"	
18 Jan., 1794,	100		Thomas Goodfellow,	"	
18 Jan., 1794,	150		David Goodfellow,	"	
18 Jan., 1794,	50		Robert Moore,	"	
30 April, 1793,	400		Samuel Marshall,	"	
14 June, 1855,	300		J. R. Lowrie,	"	Lands lying on the south face the Alleghany Mountains, and on its summit. Three-fourths of
14 June, 1855,	325		J. R. Lowrie,	"	
13 Mar., 1794,	400		Polly McEwen,	"	
13 Mar., 1794,	383		Sarah McEwen,	"	
13 Mar., 1794,	554		William and Henry McEwen,	"	

2 Sept., 1793,	350		James Swain,	"	the area is covered with rock oak and yellow pine timber.
2 Sept., 1793,	200		Daniel Stroop,	"	
2 Sept., 1793,	200		John Stroop,	"	
13 Mar., 1794,	200		Hannah Turner,	"	
	10,086				

II. LANDS ATTACHED TO COLERAIN FORGES.

15 Feb., 1786,	70	Richard Ricketts, Samuel Marshall,	Huntingdon County,	Forge tract.
1 Aug., 1766,	78	James Webster,	" "	All farm land.
3 April, 1773,	50	William Ingram,	" "	Old W. O. timber.
8 Aug., 1791,	120	Martha Russell and Middle and Lower Forge,	" "	Fine Water power.
15 Feb'y, 1786,	91	Richard Ricketts, Jno. Stonebreaker, part of Forge Farm,	" "	
29 Jan., 1794,	413	Margaret Speer,	" "	On both sides of Tussey Mountain; well set in good timber.
29 Jan., 1794,	395	Alexander Speer,	" "	
29 Jan., 1794,	404	Othniel Speer,	" "	
29 Jan., 1794,	410	Joseph Welch,	" "	
29 Jan., 1794,	408	Haniele Straw,	" "	
29 Jan., 1794,	407	Sarah McCracken,	" "	
4 June, 1762,	45	Heister's land,	" "	Splendid water power.
1 Aug., 1766,	51	Robert McKnight,	" "	Barrens ore land.
8 April, 1803,	216	Pine Hill [Penn's Manor],	Blair County,	Sinking Valley.
	3158			

III. LANDS ATTACHED TO PENNSYLVANIA FURNACE.

25 Sept., 1786,	873		Adam Bredin and William Kerr,	Huntingdon County,	Kerr and Bredin Ore Bank.
24 Sept., 1810,	193		David Johnston,	" "	
24 Sept., 1810,	84		John McWilliams,	" "	
8 June, 1808,	150		Leonard Hartline,	" "	
9 Oct., 1811,	77		John Hostler,	" "	Hostler Ore Bank.
4 Nov., 1801,	301		Peter Crispin, N. Gerrard, Jos. Morgan,	" and Centre Co.,	Furnace and Farm.
1 Aug., 1766,	80		John Wrye,	" County,	Farm.
1 Aug., 1766,	11		Scruthers,	" "	"
1 Aug., 1766,	12		John Morrison,	" "	"
1 Aug., 1766,	21		Bailey Mill Tract,	Centre County,	Grist Mill.
2 Aug., 1784,	153	92	Isaac Whorrel,	"	Pennsylvania Furnace Pipe Ore Bank and Adjoinders.
6 Sept., 1813,	382		Samuel Duncan,	"	
3 Aug., 1784,	65		James Wilson,	" and Huntingdon,	
4 Nov., 1801,	209		Peter Crispin,	"	
28 Feb'y, 1785,	100		John Hanna,	"	Whorrel Ore Bank.
22 Jan., 1829,	150		Jos. Barnett, Batman residue,	"	
28 Feb'y, 1785,	151		Lydia Fowler,	"	
6 Jan., 1814,	218		Jacob Underwood,	"	

Date of Warrant.	Actual Contents. *Acres.*	*Perches.*	Name of Warrantee.	Location.	Remarks.
8 Oct., 1784,	87		William King,	Centre County,	
26 Aug., 1794,	103		Levi Hollingsworth and Jos. Barnett,	"	Gatesburg Ore Field.
9 Mar., 1785,	126		Samuel Bryan,	"	Lytle Bank, "
9 Mar., 1785,	308	80	Richard Whitehead,	"	Bryan Bank "
6 Sept., 1816,	91		Jacob Way,	"	Bull Bank, "
15 Mar., 1820,	417		Henry Floyd,	"	The lands covered by these surveys, commonly termed "Barrens," are a light loam, sometimes sandy but generally easily turned into good farms. They are covered with a young growth of thrifty timber, and full of iron ore. The L. C. and S. P. Creek Railroad traverses many of the surveys and brings all of them into easy access.
30 April, 1793,	217		John McKissick,	"	
24 Sept., 1792,	400		William Lambourn,	"	
4 Oct., 1827,	136		Jacob Pyle,	"	
26 June, 1792,	400¾		Richard Joliff,	"	
26 June, 1792.	400¾		James Baker,	"	
26 June, 1792,	400¾		J. Petherbridge,	"	
26 June, 1792,	400		Benjamin Horner, Sr.,	"	
26 June, 1792,	315		Jacob Baker,	"	
26 June, 1792,	233		John Baker,	"	
26 June, 1792,	100		Robert Rankin,	"	
26 June, 1792,	117		Isaac Buckbee,	"	
26 June, 1792,	117		Josiah Lusby,	"	
26 June, 1792,	1353		Lots in Liebenthal, parts of survey are in the names of Richard Mosley, H. Manley, Benjamin Horner, Jr., Caleb North, and Isaac Buckbee,	"	
22 Jan., 1829,	135		Joseph Barnett,	"	
	176		William Butler and Ed. Miles,	"	
27 July, 1815,	323		John Anderson,	"	
21 Nov., 1785,	130		Jacob Liter,	"	
16 Dec., 1811,	162		George Colmeyer,	"	
18 May, 1786,	200		Joseph Nice and George Nice,	"	
29 Jan., 1794,	402		Ann Lamb,	Huntingdon County,	These surveys lie on Tussey Mountain, north & south slopes, and are covered with a fine growth of timber.
29 Jan., 1794,	402		James Lamb,	" "	
29 Jan., 1794.	399		Elizabeth Hamilton,	" "	
29 Jan., 1794.	407		Thomas Hamilton,	" "	
29 Jan., 1794.	399		Esther Moore,	" "	
29 Jan., 1794,	399		Robert Moore,	" "	
29 Jan., 1794,	405		Sarah Hastings,	Centre "	
29 Jan., 1794,	400		John Hastings,	" "	
29 Jan., 1794,	403		James McCracken,	Huntingdon "	
29 Jan., 1794,	398		Daniel Turner,	Centre "	
29 Jan., 1794,	400		Hannah Turner,	" "	
29 Jan., 1794,	404		James Moore,	" "	
29 Jan., 1794,	418		Aaron Levy,	" "	
29 Jan., 1794,	404		Thomas Ferguson,	" "	
17 Aug., 1849.	388		Alfred B. Crewit,	" "	

21 Jan.,	1794.	260	James Ash,	Huntingdon	County,	These surveys lie on the south side of Tussey Mountain, and are growing up with young timber.
21 Jan.,	1794,	250	William Shannon,	"	"	
21 Jan.,	1794,	370	George Bingham,	"	"	
21 Jan.,	1794,	820	Cadwallader Evans,	"	"	
21 Jan.,	1794.	405	Philip Sickle,	"	"	
2 Nov.,	1784.	369	William Bracken,	"	"	
24 Dec.,	1792,	180	Joseph Kuhns,	Centre	"	Lying on north slope of Brush Mountain; they present four miles of Fossil ore veins.
24 Dec.,	1792,	119	Abraham Kuhns,	"	"	
24 Dec.,	1792,	91	Isaac Kuhns,	"	"	
24 Dec.,	1792,	247	George Kuhns,	"	"	
24 Dec.,	1792,	226	Michael Kuhns,	"	"	
24 Dec.,	1792,	390	Mathias Kuhns.	"	"	
		19 329	Total of Pennsylvania Furnace Lands.			

IV. LANDS ATTACHED TO BALD EAGLE FURNACE.

8 Oct.;	1784,	300	Samuel Magan.	Blair	County,	Furnace Improvements: Mill Store, Warehouse Mansion and 300 acres cleared land.
12 Oct.,	1785.	389	John Hoffman,	"	"	
3 Aug.,	1784.	223	Ann Massey,	"	"	
24 June.	1794.	52	Joel Harlan.	"	"	Smooth valley lands, susceptible of high cultivation for farms. Traversed by the Bald Eagle Valley Railroad.
24 Aug.,		120	George Anshutz.	"	"	
24 Jan.,	1827,	280	Peter Moore,	"	"	
24 Aug.,	1814.	187	George Anshutz,	"	"	
18 Dec.,	1784.	270	Joseph Downing.	Centre	"	
8 Dec.,	1784.	301	Samuel Downing,	"	"	
8 Dec.,	1784,	395	Abner Webb,	"	"	
9 Sept.,	1807,	420	Daniel Hoffman,	Blair	"	All these lands, when cleared, make the best of grazing farms. They are well watered, and lying convenient to the Bald Eagle Valley Railroad and the Philipsburg Railroad. Are now thickly set with a thrifty second growth of timber.
8 Aug.,	1824,	412	Francis Gardner,	"	"	
7 Feb'y,	1812,	113	C. Baughman,	"	"	
6 July,	1795.	280	William Burge,	Centre	"	
18 Jan.,	1794,	150	John Hover,	"	"	
18 Jan.,	1794,	160	John Sherrick,	"	"	
18 Jan.,	1794,	100	James Adams,	"	"	
17 April,	1793,	400	Jane Craig,	"	"	
18 Jan.,	1794,	160	Nathaniel Adams,	"	"	
17 April,	1793,	319	Margaret Craig,	"	"	
6 July,	1795,	433	Joseph Dreak,	"	"	
6 July,	1795.	200	George Rite,	"	"	
28 Jan.,	1800,	179	Moses Coats,	"	"	
6 Dec.,	1837,	836	Elijah Merryman,	"	"	
1 July,	1829,	150	Andrew Berryhill,	"	"	
8 Sept.,	1794,	376	G. F. Alberti,	"	"	
8 Sept.,	1794,	211	Nicholas Hammond,	"	"	

Date of Warrant.	Actual Contents. Acres	Actual Contents. Perches.	Name of Warrantee.	Location.	Remarks.
20 Mar., 1854,	200		Robert Campbell,	Centre County,	
2 Jan., 1854,	363		William Addleman,	" "	
14 Jan., 1794,	40		James Fox,	" "	
13 Mar., 1794,	150		Thomas Maston,	" "	
13 Mar., 1794,	150		Richard Whitehead,	" "	
2 July, 1792,	400		Job Packer,		Pennington Ore Tract.
12 Oct., 1795,	72		Thomas Kerr,		Dorsey & Phillips' Tract.
	8291				

Tyrone Forges,	10.086
Coleraine "	3 158
Pennsylvania Furnace,	19 329
Bald Eagle "	8 291
	40,864 acres held in fee simple.

V. Lands on which Lyon, Shorb & Co. possess Ore Rights in common with G. & N. H. Shoenberger.

Date of Warrant.	Acres	Name of Warrantee.	Location.	Remarks.
24 Dec., 1792,	402	Benjamin West,	Huntingdon County,	
24 Dec., 1792,	397	Stephen Kingsbers,	" "	
24 Dec., 1792,	400	John Taylor,	" "	Cale Hollow.
24 Dec., 1792,	394	David Stewart,	" "	
23 July, 1766,	100	James Armitage,	" "	
24 Dec., 1792,	395	John West,	" "	
24 Dec., 1792,	408	Patrick Moore,	" "	
28 Aug., 1790,	426	James Smith,	" "	
24 Dec., 1792,	404	Robert Rainey,	" "	
7 Aug., 1793,	416	John Jackson,	" "	Dry Hollow Bank.
24 Jan., 1794,	290	Caleb Harlan,	" "	
24 Jan., 1794,	393	Charles Risk,	Centre "	
24 Jan., 1794,	400	Henry Hill,	" "	
15 Sept., 1812,	280	George Anshutz,	" "	
24 Dec., 1792,	394	Thomas Moore,	" "	
24 Dec., 1792,	426	Thomas Smith,	" "	Wrye Bank.
24 Sept., 1832,	132	John McGuire,	Huntingdon "	
23 July, 1812,	280	Jacob Keith,	" "	Weight Bank.
24 Dec., 1792,	196	Susanna Massey,	" "	
24 Dec., 1792,	422	John Hall,	" and Centre County,	
12 Jan., 1793,	328	William Birdsall,	" County,	Pennington Range.

6 July,	1793,	560	D. Porter,	Huntingdon County,	
2 Sept.,	1793,	456	William Stout,	Blair "	On the summit and north slope of Brush Mountain.
2 Sept.,	1793,	192	Charles Stout,	" "	
2 Sept.,	1793,	234	Robert Stewart,	" "	North slope of Brush Mountain, having the Fossil ores for five miles.
2 Sept.,	1793,	238	George Stout,	" "	
2 Sept.,	1793,	237	Thomas Sutton,	" "	
2 Sept..	1793,	249	Thomas Carr,	" "	
2 Sept.,	1793,	401	John Carr,	" and Centre County,	
18 May,	1786,	389	Philip Hevener.	Centre County,	
18 May,	1786,	401	Jacob Shuler,	" "	
		10,638			

VI. IN LANDS SOLD BY LYON, SHORB & CO. THE EXCLUSIVE ORE RIGHT IS RESERVED ON THE FOLLOWING SURVEYS.

9 Mar.,	1787,	427	John Romberger,	Centre County,	
21 June,	1790,	323	William Van Puhl,	" "	
18 May,	1786,	200	Joseph and George Nice,	" "	
26 June,	1792,	400	William McKean,	" "	
26 June,	1792,	400	John McKean,	" "	
26 June,	1792,	200	Caleb North,	" "	
26 June,	1792,	200	R. Rankin,	" "	
28 Feb'y,	1785,	200	John Hanna,	" "	
	1766,	50	Joseph Branstetler,	" "	McGlathery Bank.
	1766,	20	Joseph Beck,	Huntingdon County,	Newtown Bank.
8 Oct.,	1784,	160	William King,	Centre County,	
9 Mar.,	1785,	115	Samuel Bryan,	" "	
		2695			

The lands enumerated in the above Schedule, held in fee simple by Lyon, Shorb & Co., aggregate upwards of 40,000 Acres, of which 11,000 are rich in Pipe Ores and other Brown Hematites.

The ore rights on lands sold by Lyon, Shorb & Co., but reserved in perpetuity to them, cover 2,695 acres. The ore rights held in connection with G. & J. H. Shoenberger cover 10,400 acres. The Fossil Ores extend for 11 miles on the North Slope of Brush or Bald Eagle Mountain. Among the lands enumerated are 1,000 acres of Farm land cleared and in the highest possible cultivation, divided among four farms, with the best dwellings, barns, &c. There are five Grist Mills driven by permanent and abundant water power, and well located for merchant work on the several railroads. There are 136 Tenant houses on the lands connected with office and store, warehouse buildings, required to carry on the manufacture of Pig Iron at Pennsylvania Furnace and Blooms at Colerain and Tyrone Forges. The machinery and buildings in use at this Furnace and these Forges are considered by their owners as having no superior in the United States for convenient and economical production of Pig Iron and Blooms.

LIBRARY
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IRON ORES

OF THE

CUMBERLAND VALLEY.

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THE IRON ORES OF THE SOUTH MOUNTAIN

ALONG THE LINE OF THE HARRISBURG AND POTOMAC RAILWAY, IN CUMBERLAND COUNTY, PENNSYLVANIA.

(*Read before the American Philosophical Society, January* 3, 1873.)

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The Harrisburg and Potomac Railroad, starting from Harrisburg and running along the North base of the South Mountain, has for its objective point Shepherdstown on the Potomac, but its Western terminus has not yet been absolutely determined. It follows the Yellow Breeches Creek along the North foot of the South Mountain in Cumberland County, Pennsylvania. It runs parallel to Cumberland Valley Railroad, and distant from it, on an average, from four to six miles.

The Cumberland Valley is divisible into two parts, or belts, the one being slate land, the other limestone land. The Cumberland Valley Railroad may be taken as the line of demarcation between these two belts of Lower Silurian outcrops, running as it does nearly along the northern and northwestern edge of the limestone land. The interval, therefore between the two railroads is all limestone land.

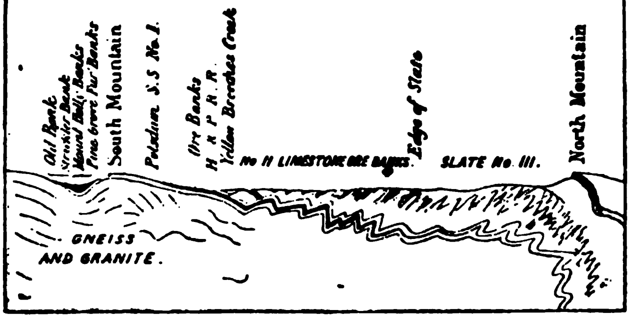
This limestone belt is full of nests, pockets and strips of brown hematite ore, some of them small, others large. They have been opened by the farmers in, at least, sixty places between Mechanicsburg and Cleversburg, a distance of thirty miles. Fifty-seven of these ore-diggings are marked upon the map which accompanies this paper. But the number of ore deposits is indefinitely great. Probably several hundred mines, great and small, might be opened. Those actually opened are mostly mere trial pits from which a few hundreds or thousands of tons of ore have been dug, at the convenience of the farmers, and sold to the small charcoal furnaces built at different times during the last half century. No scientific exploration has ever been undertaken to test their real size, width, length and depth; nor has any geological tracing of the deposits into each other been made. The whole may considered unexplored ground. No geologist can doubt for a moment that large quantities of wash ore, clay ore, rock ore and pipe ore lie concealed under the surface soil of the fields.

Passing to the south side of the Harrisburg and Potomac Railroad the geologist finds himself on a belt of country of a different kind, full of deposits of brown hematite iron ore, belonging to another and older series. To make this clear, I must give an ideal cross-section of the valley and the mountains which bounds it on the north and on the south. See Fig. 1.

It will be seen from the diagram below that the geological formations Nos. I, II, III and IV, resting upon each other and forming the Lower Silurian system, crop out southward from under each other ; so that, No. IV sandstone forms the North Mountain ; No. III slate, the northern half of the valley ; No. II b. limestone, the southern half of the valley between the two railroads ; No. II a. calciferous sandrock, the foot slopes of the South Mountain south of the Harrisburg and Potomac Railroad ; and No. I, Potsdam slates and sandstones, the facing and top of the mountain, resting on massive gneiss rocks forming the body of the mountain.

FIG. 1.

CROSS SECTION OF CUMBERLAND VALLEY AT CARLISLE.



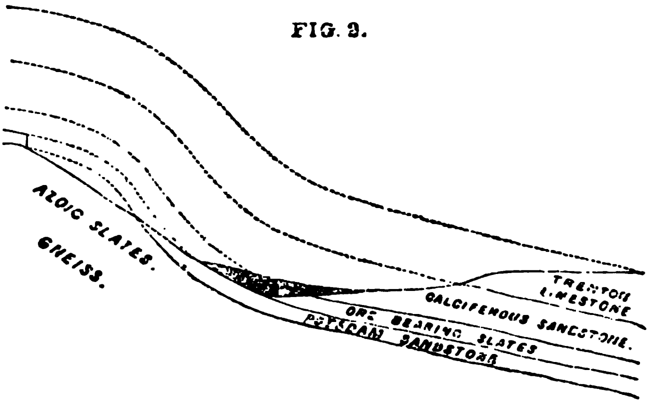
My object is to show that the ore deposits of the South Mountain face must needs be geologically *continuous*. For I have in other memoirs demonstrated that the ores are in fact nothing but the original rocks themselves from which all or nearly all the limestone has been dissolved out, leaving the clay, sand and iron behind. They are not washings of ore from distant regions, dumped down at hazard in hollows of the surface and therefore of uncertain occurrence and quantity. They are perfectly well-defined and continuous strata, occupying the position they always occupied, and following the sides of the mountains, the course of of the principal stream, and the strike of the harder limestone ledges, along the whole course of the valley.

They never occur in any other relationships. They are the same ores, in the same rocks, arranged in the same way, the whole distance from Massachusetts to Alabama. Consequently, whatever is geologically true of the ore beds at Salisbury and Armenia east of the Hudson ; at Balliot's, Trexlertown and Moselem west of the Lehigh ; at Mont Alto and Antietam north of the Potomac ; at Embreeville in East Tennessee ; at Shelbyville in Alabama ; is equally and in the same sense and for the same reason true of the Old Bank, &c. at Boiling Spring, the Big Pond, Clever's and other banks along the line of this Harrisburg and Potomac Railroad in Cumberland County, Pa.

I. *As to their situation.* This belt of deposit runs along at the foot of the mountain slope, rising upon it in one direction (south) and sinking in the other direction (north) beneath the Yellow Breeches Creek and the limestone country north of it. But although there is a continuous belt of ore, the thickness of the deposit varies from mile to mile; as also does its width upon the surface.

Formerly the slates which held the iron which mouldered into ore, rode up on the side of the mountain in a continuous sheet, resting on the great Potsdam Sandstone rock which is seen still resting upon the mountain in places forming peaks and plateaux upon its side and summit. But great erosion has taken place, and in this erosion the slates have suffered most, because of their soft, clayey nature, and because they contained a large percentage of soluble limestone with the oxidizable iron. The above diagram will show how this has been accomplished: See Fig. 2.

FIG. 3.



As the erosion went on, the oxidized iron slipped with the heavy clays slowly downwards, the whole mass pressing upon itself and crimpling as it slid. The corrugations thus produced are visible in all the ore-banks.

Some of the strata in the slate formation were more clayey; others more sandy. Some held more iron; others less. Hence we see great masses of white clay parting the masses of ore in all the banks. We see in one part of a bank wash ore; in other parts solid ore. Hence also we find in one place ore made cold-short by an overplus of silica (?); in another place a red-short ore due to an overplus of lime holding sulphurous traces; in others a surplus of manganese; in others again the ore is is neutral. All these variations are due to differences of original composition in the different strata of the slate formation. And these variations follow the outcrops along the foot of the mountain in a waved line riding up its side or sinking into the plain.

The above description is true of the whole range along the foot of the mountain from Papertown westward to Cleversburg, and on into Maryland. But east of Papertown the mountain begins to sink into the plain of the Susquehanna River. The slate formation laps around its end and runs up behind its first ridge, carrying, of course, the ores with it. To explain this I must describe the structure of the mountain mass.

The South Mountain is not one mountain, but a system of parallel mountains separated by valleys. It is, geologically considered, a system of anticlinals with troughs between.

The first or northernmost anticlinal comes to an end (eastwardly) west of Papertown.

The second anticlinal begins to sink after passing east of Papertown. And it carries down with it into the limestone plain the mountain east of Papertown.

The slates which carry the ore, once arching continuously over the top of the present mountains, descend into the interior valleys. This accounts for the great banks at Mount Holly, half a mile south of Papertown, and the ore banks along the whole line of the Mountain Creek as far as Pinegrove Furnace.

At the Strickler bank, marked 6 on the map, the ore is seen lying in a trough between two mountains; and the Potsdam Sandstone is seen descending *southward* from the top of the mountain and passing under the floor of the ore bank. And the ore continues eastward along the centre of the trough to the Old Bank. North of the Old Bank the limestones of the valley are seen dipping southward. The north dipping ore-slates follow the foot of the mountain eastward to the New Pitts (3 on the map) opposite Boiling Springs.

The third anticlinal here begins to sink eastward, and the slates and ores lap round its end and run up into the next trough to the south of it where we have the Beltzhoover and Red Banks (2 and 1 on map).

The fourth anticlinal runs on a mile or so still further east and in its turn dies down; the slates, limestones and ore lap round it and take up their regular position at the south foot of its mountain, giving us the Knaub and Wolf Banks (20 on the map). The fifth and most southern anticlinal dies down in front of Dillsburg, and the slates and ores lap round it as usual and give us the McCormick and Williams banks.

It appears then that the South Mountain Range ends eastward in a hand with five fingers. Its little finger, and the most northern one, ends at Papertown (or less than a mile to the north of it); the next finger ends at the Old Bank; the third, at Boiling Springs (or rather one mile east of that place); the fourth and longest of them all, at the mouth of Dogwood; and the fifth or most southern one, opposite (one mile west of) Dillsburg.

Around these fingers, the ore belt laps continuously and sends up troughs of ore between the fingers.

Such is the most general statement of the geology. I reserve details of geological structure for the close of this note: merely alluding here to the fact that any one possessing the key to the geology can perceive a perfect regularity in the apparent confusion of the deposits.

II. *The quantity of ore* in this belt depends on three considerations, all of them variable:

First: On the original charge of iron in the slate and calc-sand strata.

Second: On the dip of these strata as they descend from the side of the mountain.

Third: On the depth beneath water-level to which the mouldering decomposition of the strata and the peroxidation, concentration and crystalization of the iron has extended.

First. It is not to be expected that the slate formation as a whole was equally charged with iron everywhere. Consequently at some points along this belt (of 20 miles) a greater quantity of ore is to be expected, and a deficiency of ore in the intervals. It is probable however that workable quantities will be found on almost, if not on quite, every mile of the belt. In five or six parts of the belt ore exists in millions of tons. At no one point have scientific mining operations revealed more than a small portion of the actual length, breadth and depth of the ore. At some places the intervals between two large mines are evidently occupied by ore to the same extent as at the mines actually opened. It is safe, for instance, to consider the whole interval between the Old Bank and the Strickler Bank as a continuous deposit of ore.

Second. A steep dip narrows the outcrop of ore; a gentle dip broadens it. At the new pits opposite Boiling Springs the dip is about 6°, almost that of the surfaces; consequently, pits sunk anywhere on the gentle foot-slope of the mountain over a space 1000 to 1500 feet wide and from half a mile to a mile long, strike ore within five or ten feet of the surface (sometimes at the surface) and go down through it to an unknown depth, at least 25 feet.

Third. This dip, whether steep or gentle, carries the ore down northward under the Calciferous Sandstone in which the Yellow Breeches Creek has cut its course. How far the ores can be followed down, northward, under the bed of the creek toward the interior of the Great Valley, and whether or not shafts of 500 to 1000 feet sunk on the north bank of Yellow Breeches Creek would strike the slate formation in a decomposed condition, that is, in the form of clays holding iron ores, no one can tell until trial be made; but there is every reason to believe that the ore mined at the surface, at the foot of the mountain, forms in quantity but a small portion of the whole production of ore to be got hereafter under the valley of the creek.

From these considerations, I judge that the quantity of ore attainable by proper mining operations has no easily assignable limit, and may furnish supplies for centuries.

The present survey was expressly limited to the iron ores on the line of the Harrisburg and Potomac Railroad in *Cumberland* County, Pennsylvania; but the ore deposit is geologically continuous along the South Mountain from the Susquehanna to the Potomac and beyond.* In addition to numerous outcroppings and surface developments the ores have been long and extensively worked on the old Southampton Furnace property, three miles west of of Cleversburg, at Old Pond on the Caledonia estate opposite Chambersburg. at Mount Alto three miles east, at Mount Etna ten miles southwest of Waynesboro', and near Antietam Furnace on the Potomac.

III. *Details.* These will be understood by reference to the following diagrams and to the accompanying map.

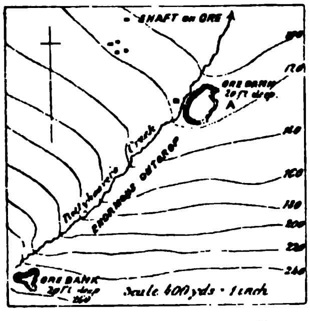
A. MOUNTAIN HEMATITES.—The most eastern point of development of these ores, on the line of the railroad, is on the property of the Carlisle Iron Works, about three miles east from Boiling Springs.

No. 1.† *Red Bank*—Lies 2½ miles east 35° south from Boiling Springs, and is opened immediately on the bank of a good, never-failing stream, which would afford an abundance of water for washing, not only at this bank, but for a mile west. The opening is small, only a few tons of ore having been taken for testing at the furnace. The ore shows very red and full of fibrous brown hematite, like the Alabama ore, but with crystals only ⅛, ¼, and ½ inch long, radiating and a little curved. The cavities are small, and lined with fibrous crystalline walls.

The quality of the ore is reported very good, producing, without admixture, a neutral iron.

No estimate can be made of the mass of ore here, as the opening has only gone down a few feet in the anhydrated (blood red) top-wash ore. The opening is 190 feet by barometer above the Yellow Breeches Creek, at the bend at Hoffer's, north of the bank.

FIG. 4.



No. 2. The exposure here consists of two old ore pits, marked A and B, on the accompanying sketch, Fig. 4, and some trial shafts. The banks lie 2 miles east 45° south from Boiling Springs, and one-half mile west of Red Bank, No. 1.

Pit A shows an opening of about 80 yards in length, by 18 to 20 yards in width, and from 7 to 8 yards in depth. Pit B is small, showing an opening about 20×10×7 yards.

The banks lie upon the side of Beltzhoover's Creek, a small, scantily-fed stream, now entirely dry. All the way up the creek, from A to B and beyond, are lumps and masses of splendid ore, some of great size. At both banks the lumps and wash ore reach from within two or three feet of the surface to the bottom, a distance of 20 feet. The bottom in both banks is solid ore. Much white clay, creeping down hill, covers the ore, and is covered by ball and wash ore. The contour lines on the sketch show a fall of 140 feet from Pit B to the trial shafts, giving a gentle dip of 4° to 5° to the northward. The ore is struck in every case close to the surface, and has the same dip. In Pit B the ore is especially marked by the great abundance of needle ore.

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* See my description of the Palo Alto mines in Proceedings of the American Philosophical Society, Vol. X, p. 463, ff. Dec. 1864.

† These numbers refer to points so numbered upon the accompanying map, and not to any local nomenclature.

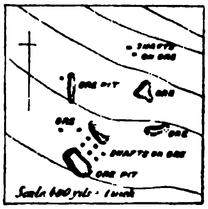
All the ore taken from these pits has been smelted at Boiling Springs Furnace, and is highly commended.

Over ten thousand cubic yards of excavation have been made at the two pits, yielding, after allowing for the dry and thinner wash-ore near the surface, some 15,000 tons of ore. As the solid ore in the bottom has never been worked through, it is impossible to estimate the mass of ore in sight.

Pit B is 240, and Pit A 120 feet above the Yellow Breeches Creek. Beltzhoover's Creek would afford but a scanty and insecure supply for a washer, but water could readily be brought from the Red Bank Creek, the difference in height by barometer being about 70 feet, and the distance, as paced between Red Bank (No. 7) and Pit A, one-half mile.

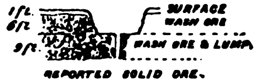
No. 3. This exposure consists of some small, old pits and a few trial shafts put down only until the solid ore was reached about 1¼ miles south 35° east from Boiling Springs, see Fig. 5. The pits and shafts are shallow, showing in the deepest from 15 to 18 feet wash and lump ore, with ore in the bottom. The ore is struck everywhere near the surface, and the dips would therefore be, as shown by the contour lines, 4° to 5° to the north ward. The ore was used at the Boiling Springs Furnace, and was satisfactory. The total amount of excavation in these small pits will not exceed 3500 cubic yards, or 5000 tons of ore. Water for washing would have to be brought or pumped, there being no stream running by the banks. The most southern and highest bank is 150 feet by barometer above the Yellow Breeches, at Hoffer's Bend.

FIG 5



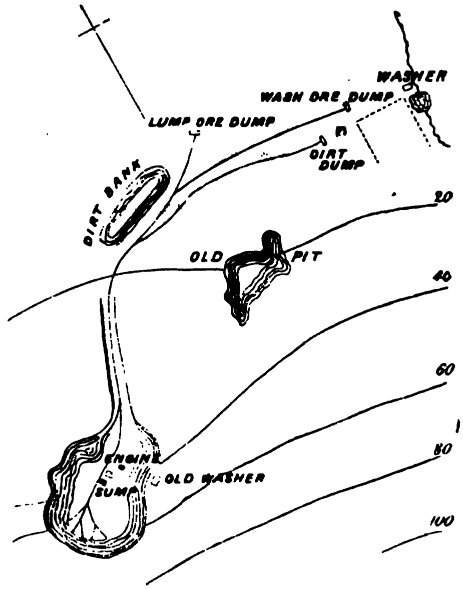
No. 4. *Siplinger Bank*—Lies 1¾ miles south of Boiling Springs, on the bank of a small stream amply sufficient for washing. The bank has not been worked for many years, and the sides falling have nearly filled it up. The wash ore is deep red, and the bank closely resembles in general appearance the Red Bank, No. 1. It is impossible now to judge the number of cubic yards of excavation made, but probably 2000 tons of ore have been hauled to the Boiling Springs Furnace, where it worked well. A poor exposure in the bank shows thus: (Fig. 6.)

FIG. 6.



No. 5. *Old Bank.*—Lies 2⅓ miles south 18° west from Boiling Springs, on the edge of good and sufficient washing stream. The bank is now worked, and makes a large excavation. The rough sketch in Fig. 7, shows the size of the bank, depth, tramroads, washer-engine, etc. The main hole is 70 feet below the surface at its southern end. The floor is solid ore, and on the south face shows a beautiful arch of ore. In addition to these 70 feet of wash and lump ore in sight, the dump has been sunk 28 feet through ore, leaving solid rock ore still below, making a total of 100‸feet.

FIG. 7.



OLD BANK CARLISLE IRONWORKS.

Scale 400 feet to an inch.

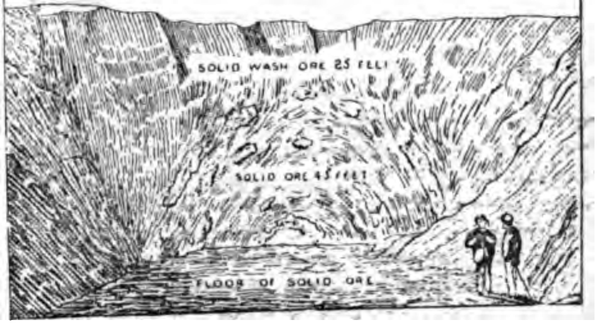
The quality of the ore is very high. It is used at Boiling Springs Furnace in the proportion of 75 to 85 per cent. to 15 to 25 per cent. of limestone hematites, or magnetic ores. The iron made is of the finest quality, and when made into blooms at the forge attached to the furnace commands the highest market price. During the war the metal was tested at Knapp's foundry near Pittsburgh, and was found excellent for gun metal. The excavation at the Old Bank shows about 40,000 cubic yards, or 60,000 tons of ore removed. From the long-abandoned pit just east of the bank, the depth of which could not be measured, as the pit was full of water, some 15,000 to 20,000 cubic yards, or 25,000 to 30,000 tons of ore, seem to have been taken out.

All these openings, from the Red Bank, No. 1, to the Old Bank, No. 5, are on the property of the Carlisle Iron Works, the boundary line of the tract (10,000 acres) being marked on the map. A charcoal furnace, attached to the property, has been running for nearly eighty years, fed by ores from these banks above mentioned, with slight admixture of magnetic or limestone ores. Probably 150,000 tons of this mountain hematite have been mined from their banks for their furnace.

This furnace property now known as "Carlisle Iron works," and belonging to C. W. and D. V. Ahl, was formerly owned and for many years worked by Michael Ege. The furnace has been lately extensively improved with new hot-blast and blow-house, additional tuyere, increased blast, &c., and the weekly production of metal raised to 45 or 50 tons.

The power is entirely water, supplied in abundance by Yellow Breeches Creek and a group of powerful springs on the property.

FIG. 8.
ANTICLINAL ARCH OF ORE, IN THE HEADING OF THE OLD BANK, BOILING SPRINGS, CUMBERLAND CO. PENNA.



The development at the Old Bank is sufficient to enable estimates to be made of ore in sight along the range. Taking a prism of ore from the Old Bank to the Strickler Bank (No. 5 to No. 6), nearly a mile west, and assuming less than one-half the thickness of ore showing at the Old Bank, 15 instead of 33 yards, we have 1600×15×1=24,000 cubic yards, or

36,000 tons of ore for every yard driven back southward on the mountain. For a depth of 100 yards back, which is the depth now at the Old Bank, we have 24,000×100=2,400,000 cubic yards, or 3,600,000 tons of ore as the product of a bank reaching from the Old Bank to the Strickler, running back 100 yards, and cut down from top to bottom through 15 yards of lump and wash ore. But there is no reason why this prism should not be extended to the eastward as far as the ore is proved, say to Red Bank No. 1, the distance along the course of the ore being just five times 1600, or 8000 yards; and reducing the estimated thickness to 22½ feet for security, we have $3,600,000\times\frac{5}{2}=9,000,000$ tons, a practically indefinite amount with only 100 yards extension into the mountain. There is, of course, no reason for fixing 100 yards as the limit, except for purposes of computation. After these figures it is scarcely necessary to compute the probable mass of ore sweeping eastward from the Red Bank (No. 7) around the eastern end of the South Mountain to the Knaub Bank.

No. 6. *Strickler Bank.*—Lies three miles south 32° west from Boiling Springs. Sketch, Fig. 9, exhibits the relative size of the bank, machinery for working, etc., and cross-section Fig. 10, shows the 20 feet of lump and wash-ore now being worked. In addition to this, the Superintendent states that the sump, 26 feet deep, was sunk entirely through ore, having solid ore in bottom. The present excavation shows about 12,000 cubic yards, or 16,000 to 18,000 tons of ore removed; 18 tons of ore a day are now being shipped. The bank has water to wash 75 or 80 tons a day, but not machinery.

FIG. 9

STRICKLER BANK.

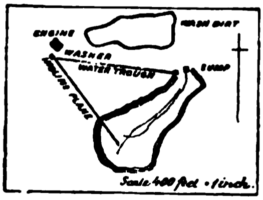
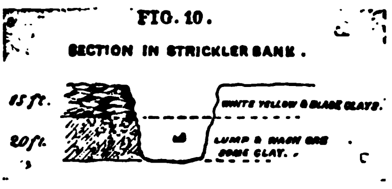


FIG. 10.

SECTION IN STRICKLER BANK.



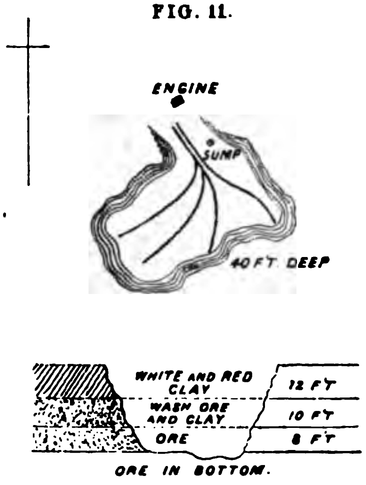
No. 7. *Papertown Banks.*—Two ore banks are opened here, and are now being worked. They lie just inside the Papertown Gap. The southern of the two—the Wyncoop-Medler Bank—is roughly sketched in Fig. 11. Large quantities of manganese are in these beds.

The present working face of ore, as shown in the cross-section, gives 18 to 20 feet of wash and lump ore in sight, with ore in the bottom. This is at the southern and western sides. At the northeastern end the bottom of the ore is reached and the sump is not through ore. The dip is to the southward and very decided, the present bank going directly across the ore bed, the total thickness of which, vertically, must be very great. The operators are now shipping about 40 tons of ore a day. They have machinery to wash 150 tons a day, but water only for from 40 to 60 tons a day as supplied at present.

The Northern, or *Kirkslager* Bank is sketched in Fig. 12. It lies 175 yards northeast of the last. The section shows 16 to 20 feet of wash and lump ore, with ore in the floor. The dip of the ore is to the southward and the work is now running across and down the ore. The total thickness of ore at this bank is very considerable. About 40 tons of ore a day are now shipped, but the amount is soon to be raised to 1000 or 1200 tons a month. Water for washing is pumped from Mountain Creek.

WYNCOOP MEDLER BANK.

FIG. 11.

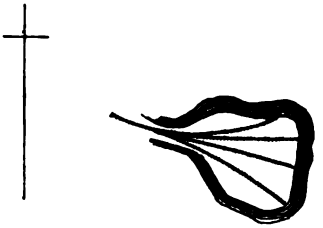


Scale. 100 Yards to an inch.

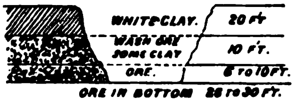
These ores are of good quality, going mostly to Harrisburg, where they are mixed half-and-half with Cornwall ore in the furnace.

The amount of ore already taken from these banks is about 25,000 cubic yards, or 37,000 tons from the Wyncoop-Medler Bank, and 20,000 cubic yards, or 30,000 tons of ore from the Kirkslager Bank. The ore bed being continuous up the valley of Mountain Creek for several miles, the amount of ore in sight is very great. Estimating the bed at six yards in thickness, which is only a small part of the vertical thickness showing at Papertown, the yield of ore would be 10,000 cubic yards, or 15,000 tons for each yard gone back on the bed, over a distance of one mile, cutting the bed 6 yards.

FIG. 12.



Scale 100yds to 1 inch.



The cost of mining ore at these banks at the present time is thus stated:

Royalty	75
Cost of mining and stripping	$1 30
Hauling, washing and handling	15
	$2 20

Price on the cars $3.50; leaving a profit of $1.30 a ton. When the price of ore is under $3.00 a ton, royalty falls to 37½ cents a ton.

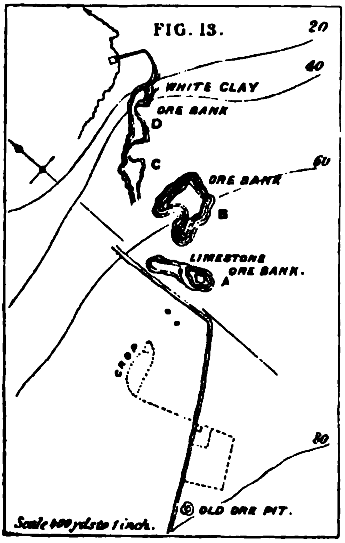
No. 8. One third of a mile east of Papertown, at the base of the South Mountain, a shaft has been put down on the ore; it was reported as going 35 feet through ore. The ore, which was used at the Old Holly Furnace, was quite cold-short. On the Siplinger Place, a short distance north of this shaft, some ore had been taken from a shallow pit.

Nos. 9, 10, 11, 12, 13, 14. These are small, shallow, long since abandoned pits from which ore was hauled to Old Holly or Augusta Furnaces; or trial shafts sunk into solid ore. They lie at irregular distances from each other, close up against the South Mountain, in a line extending from Papertown Gap west 7 miles. The pits are almost entirely filled up and no estimates can be made from them.

No. 15. *Grove & Co.'s Banks.*—These banks lie close against the South Mountain, 1 mile south of the Yellow Breeches Creek, 6½ miles south, 30° east from Newville. Augusta and Cumberland Furnaces ran many years mainly upon ores from these banks, which were extensively opened. They are now so completely fallen shut as to prevent any reliable estimates, but probably not less than 50,000 tons of ore have been taken from them. A great quantity of rich wash ore is now lying on their edges. The ore is reported to have worked well in the furnace, needing however considerable admixture of limestone ores.

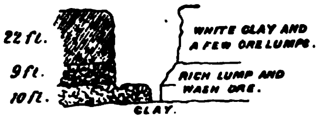
No. 16. *Big Pond Banks.*—Lie 7 miles south of Newville, 5 miles east of Shippensburg, and a-half mile northwest from Big Pond Furnace The accompanying rough sketch, Fig. 13, shows the position of the different openings, washer, &c.

FIG. 13.



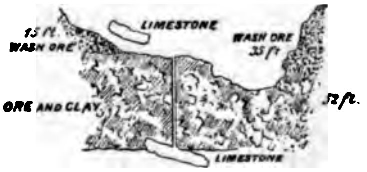
The banks exhibit a series of openings, beginning at the northeastern end of the sketch, where the ore bottom is only a few feet above the level of the stream at the washer, running to the southwestern end of the sketch, where wash ore is struck in an old ore pit near the surface, 75 feet above the stream level. Only one bank is now worked (D), and the others have washed in a mass of dirt which renders it impossible to see the actual ore depth mined out. The cross-section of D, Fig. 14, given below, is the present actual working face of ore (May). It shows 22 feet of clay overlaying 19 feet of wash and lump ore with clay in bottom not gone through. More recently the stripping has been only 6 feet with solid ore in bottom. The section of A, Fig. 15, shows limestone crop at the surface dipping south 20° east 8°, and how a shaft put down 20 yards south, went through ore and clays for 52 feet ending on limestone. The harder parts only of the limestone bed remain, the softer parts having worn away and been replaced by the ores and clays. The limestone is ferruginous and makes an excellent flux in the furnace.

FIG. 14.



SECTION IN ORE BANK D.

FIG. 15.



SECTION IN ORE BANK A.

The ore is first rate in quality. It is and has always been used in the furnace just as taken from any of the banks, without any admixture of other ores. It makes a neutral iron which has always commanded the highest market price.

The quantity of ore removed from the banks is probably altogether not less than 75,000 to 90,000 tons. The furnace has been running steadily, excepting short intervals, from 1836 to 1868, making an average of perhaps 800 tons of iron a year. The ore needful for this amount of iron would correspond with the rough estimate of cubic yards removed now possible.

Assuming 21 feet or 7 yards as the thickness of the bed, every running mile will afford 12,000 cubic yards or 18,000 tons of ore for each yard mined back on the bed.

The Big Pond Furnace property, owned by P. A. Ahl, comprises about 6,000 acres of land. The furnace has recently been entirely renovated the stack being raised to 36 feet, with a new hot-blast, building, &c. Its capacity is now over 50 tons of charcoal iron per week.

No. 17. *Southampton Bank.*—Lies 1¾ miles east 15 north from Cleversburg, and 1½ miles west 35° south from Big Pond Ore Banks. The mine is not now worked and the sides have fallen shut and the bottom become covered over. A poor exposure shows 8 feet of wash ore. This wash in sight, which was that nearest the surface, shows very lean with but few lumps. A heavy mass of white clay overlies the ore.

The ore taken from here was smelted at Franklin Furnace and is reported to work well.

No. 18. *Clever's Bank.*—Lies 1⅛ miles east 30° south from Cleversburg, on the bank of a stream sufficient for washing. The above rough sketch of the bank shows the present dimensions, Fig. 16.

FIG. 16.

CLEVER'S BANK.

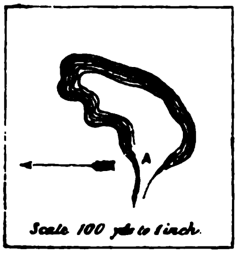
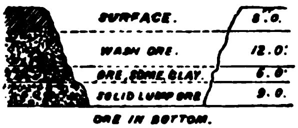


FIG. 17.



CROSS SECTION IN CLEVER'S BANK.

Cross-section, Fig. 17, shows 27 feet of lump and wash ore, ore in the bottom, and represents the working face of ore on the eastern side of the bank. At A on sketch, on the western side of the bank, the ore bottom seems to have been reached and the underlying clay has not been pierced through. The present ore shipment is about 40 tons a day.

The ore goes to Harrisburg, Reading and Columbia and is reported very cold-short.

The bank shows that some 20,000 tons of ore have been removed. With the above depth of wash and lump ore 27 feet or 9 yards each running mile yields 15,000 cubic yards, or 22,000 tons of ore for each yard mined back into mountain and cut down to the bottom of the bed for that distance.

Considerable ore has been mined around Cleversburg, the Chestnut and Coffee Banks southeast of the town having been extensively worked.

With reference to the general quantity of ore along the line of the Harrisburg and Potomac Railroad from Dogwood Run on the east to Cleversburg on the west, the above detailed estimates made at each point where the development was sufficient, are enough to show that the amount is indefinitely great, and render any further figures unnecessary.

The quality of the ore varies very much. At the eastern end the ores taken from banks (1) to (5) inclusive, used at Boiling Springs Furnace, are very slightly cold-short, permitting the use of 75 per cent. of these ores to 25 per cent. of magnetic or limestone ores.

At Papertown (No. 7) the ores are more cold-short, 50 per cent. being used in the furnace.

At Big Pond (No. 16) the ores are neutral and are used unmixed.

At Clever's Bank (No. 18) the ores are reported to be quite cold-short.

Messrs. Grove & Co., of Danville, however, who have used these ores, state that they worked well when mixed with other ores and made a fine foundry iron. Messrs. Wister of Harrisburg have also used them.

A general examination of the past and present working of the furnaces running upon these mountain ores shows that it takes about 2½ tons of ore to make a ton of metal. 130 to 140 bushels of charcoal may be put down as the average of fuel required.

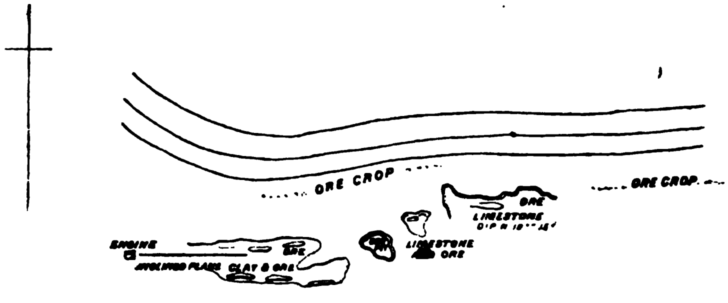
B. LIMESTONE ORES.—As shown on the map, these limestone hemafites have been examined in many places. The show consists in most places either of a very heavy outcrop or abandoned shallow pits from which ore had been taken in quantities ranging from 100 to many thousand tons. Some of the localties are now in working. The description of them all would be mere repetition; one sketch, Fig. 18, will serve as a type of their character.

No. 19. *Gutthart Bank.*—Lies 3½ miles east 20° south from Newville.

As shown in the above rough sketch, the working is done in a crevice, the limestone shutting in on both sides. The bottom of the ore-bearing clay has not been reached. At present about 12 to 14 tons a day are shipped. Water is pumped for washing.

At Cressler's Bank, 2 miles southeast of Shippensburg, there is a large excavation showing that probably 20,000 tons have been removed. It was abandoned on account of water. Mr. Cressler says that the ore did *not* lie regularly bedded with the limestone; and that when the water drove him out he was working 35 feet of pipe ore.

FIG 18.



Scale 100 Yards to 1 inch

On the Gorgas farm, near Bridgeport, on the Susquehanna, a limestone ore bank was extensively worked.

These ores, from their uniformly good quality and value for mixing with cold-short ores, are in great demand and readily bring $5 or more a ton. But the uncertainty of the shape of the deposits and their size, the large amount of clay to be handled to each ton of ore, and the cost of pumping water for washing, or using the still more costly screener, these reasons prevent any great quantity of the ore from reaching the market even at the high price named above. A thorough development of these valley ores and the discovery of large regularly bedded deposits would change the whole character of the estimate of mining expenses.

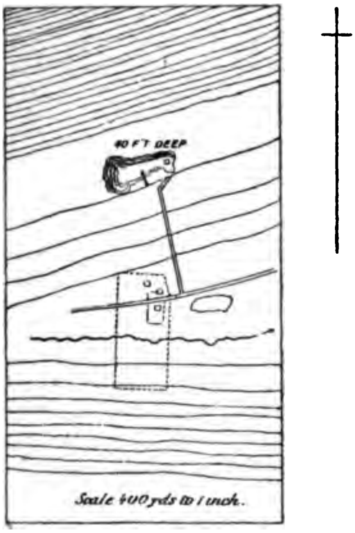
III. YORK SPRINGS BRANCH RAILROAD.—A branch railroad leaves the Harrisburg and Potomac Railroad, near the mouth of Dogwood Run, and follows that stream around the eastern end of the South Mountain, running to York Springs Burrough formerly Petersburg in Adams County. This branch now under construction, therefore, reaches the mountain hematites on the South Mountain as well as the magnetic iron ores of York and Adams Counties.

I. *Mountain Hematite. No.* 20. *Knaub Bank.*—Lies 2¼ miles west from Dillsburg. As shown by the rough sketch given below, the bank lies 80 feet above the stream which must supply water for washing. The proposed new line of the Harrisburg and Potomac Railroad passes within about 1½ miles. The bank has not been worked for some time, and the sides have fallen in. Fig. 19 shows 22 feet of lump and wash ore, with ore in the floor.

The excavation shows that some 25,000 cubic yards, or 35,000 tons of ore have been removed. About 1½ miles west 20° south from the Knaub Bank the Wolf Bank is now being opened on the same terrace on the mountain side, immediately on the bank of the same excellent washing stream. Assuming the depth of ore showing at the Knaub Bank as persistent, we have between these two banks 6000 cubic yards or 9000 tons of ore for every yard mined north and south along the dip of the bed.

No. 21. *McCormick Bank.*—Lies about 2 miles west 35° south from Dillsburg, and half a mile from York Springs Branch Railroad. The bank has not been worked for some years, and the sides have slipped down. The present face shows 10 feet of wash and lump ore, and a shaft from which ore was mined went down 16 feet in ore, making 26 feet. The ore was used in Harrisburg, and Mr. McCormick reports the quality very good. The amount of ore removed must have been quite large, as the bank was opened 60 years ago, and worked, with intervals of rest, up to 4 years ago. As the worked-out portions are filled with stripping and wash no estimate can be made of quantities. The dip of the ore is very decided, south 45° east, 25°. Mining has been done hitherto by running along the line of strike and going down the dip until the water stopped work. The expense of hauling the ore 11 miles to Mechanicsburg on the Cumberland Valley Railroad, proved heavy, and the mine was for the time abandoned. Within a half mile south 15° west from McCormick's bank, there are two old banks from which considerable ore has been hauled in the past, but which are now fallen shut.

FIG. 19.



II. *Magnetic Iron Ores.*—The branch road strikes these ores about 1 mile east of Dillsburg. There appear to be five beds, the thickness of which is *reported* as follows :

No. 1. Small. Most northerly bed.
" 2. 3 feet.
" 3. 5 to 12 feet.
" 4. 4 to 7 feet.
" 10 + feet.

The distance from No. 1 to No. 5 is from 800 to 900 yards. The beds dip north 20°. East and west along the strike of the beds for 360 to 400 yards, shallow pits have been opened on the beds, and ore taken out until the water stopped the work. These scattered openings extend over a considerable area, and, in the aggregate, much ore has been removed. At present (May) only one small pit is being worked—Mr. Underwood's. On Bed No. 3, Mr. McCormick of Harrisburg has mined a large amount of ore. He was provided with the necessary engine power and went down 80 feet, mining on slope along the dip of the ore. Gangways were then driven east and west in the ore. The expense of hauling 10 or 11 miles to Mechanicsburg rendered the works unprofitable, and the mine was abandoned and is now filled with water.

Two miles north of Petersburg in Adams County, on Lerew's place, there is an outcrop of magnetic ore. No opening has yet been made, but the place is leased and work is to begin at once.

Traces of magnetic iron ore have been found about half a mile south of Boiling Spring Furnace at the north foot of the South Mountain in connection with the trap dyke.

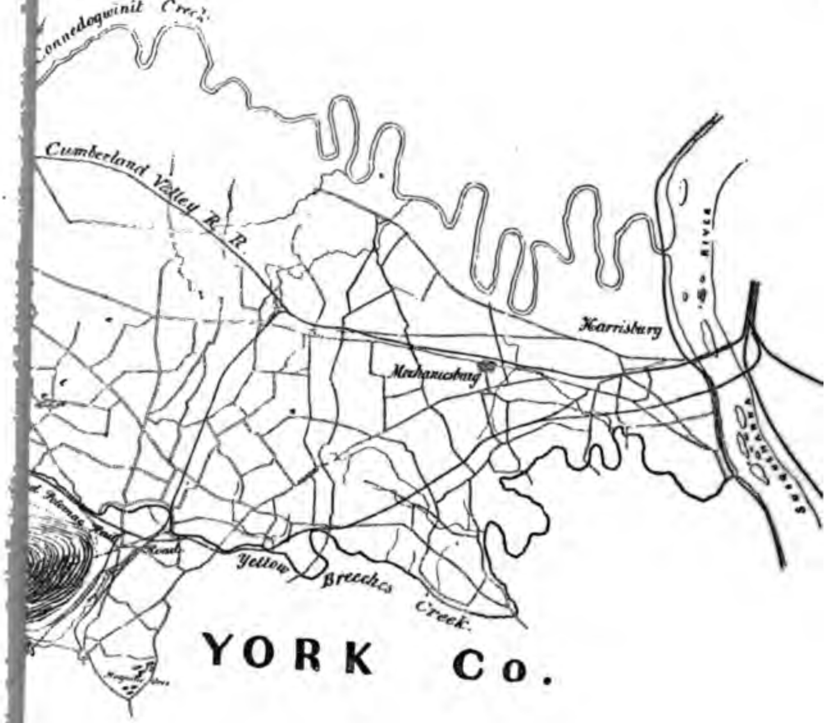
An outcrop of magnetic ore is found south of the Yellow Breeches Creek, running from the mouth of Dogwood Run east as far as Lower Milltown, on the Nelson, Nisely, Urich, Bishop, and Stayman farms. At Stayman's a pit has been sunk and the indications are reported as favorable.

One and a-half miles up Dogwood Run, specular iron ore crops at the surface. No opening has been made. An outcrop of specular iron ore is also found in the South Mountains, 4 miles south of Boiling Springs Furnace.

III. *Sand.*—At the mouth of Dogwood Run, an extensive flat is covered to a depth of 10 feet with a very pure sand. About 1000 tons have been shipped to Harrisburg for moulder's use. It is sufficiently valuable to bear a charge of $2 for hauling and freight, and with cheap transportation by railroad, would probably be shipped in increased quantities.

An excellent sand, suitable for furnace use, is opened at Boiling Springs Furnace. It lies between limestones somewhat altered, and comes from a friable altered sandstone. It is found on the "Trap-dyke Ridge." Good sands are opened at Papertown.

IV. *Limestone.*—The valley limestones, making usually the north bank of the Yellow Breeches Creek, are found along the whole line of the road; and are of all qualities ranging from burning to the hardest building stones. At Milltown, 8 miles east of Boiling Springs, 9 miles west of Harrisburg, the limestone is peculiarly excellent for burning, and about 100,000 bushels a year are now made there. The amount can, of course, be indefinitely increased with the enlarged market afforded by cheaper transportation.


Connedoguinit Creek
Cumberland Valley R. R.
Harrisburg
Mechanicsburg
Susquehanna
River
Potomac Road
Road
Yellow Breeches Creek
YORK Co.

GEOLOGICAL REPORT

ON THE

St. Clairsville and Bedford or Dunning's Creek Outcrop of

FOSSIL IRON ORE,

BEDFORD COUNTY, PA.

BY J. P. LESLEY,

Professor of Geology in the University of Pennsylvania.

PHILADELPHIA:
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1873.

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BY J. P. LESLEY, PROF. OF GEOLOGY IN THE UNIVERSITY OF PENNA.

DECEMBER 30th, 1872.

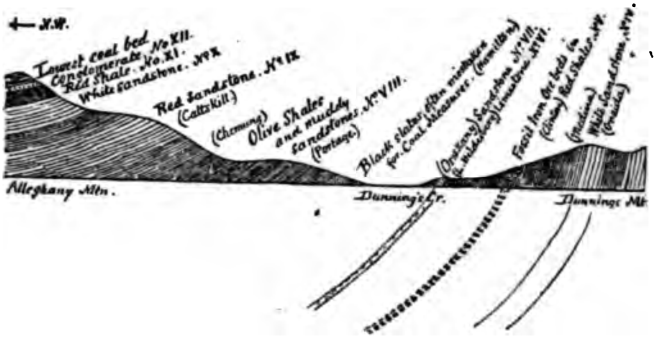
To the Hon. John Cessna, of Bedford, Pa.:

SIR:—The property which you requested me to examine, about 10 miles north of Bedford, falls within the limits of that district of the old Geological Survey assigned to Dr. R. M. S. Jackson, whose original report, dated about the year 1840, was engrossed without much alteration in the Final Report of the State Geologist. Very little was known, however, at that time, about the fossil iron ore belt in Bedford County, except its geographical position, which was accurately enough laid down on the Geological State Map, which I constructed by order of Prof. H. D. Rogers in 1842 and 1843. Since then, the outcrops of the ore beds have been mined into, or opened by trial-shafts in hundreds of places and their relative thickness and quality determined. With regard to the property here and now in question my Assistant, Mr. Franklin Platt, has made a special topographical and geological survey and sketch map to be found below; and Mr. John W. Harden a special study of the same with a view to the best way and probable expense of mining the ores.

I. SITUATION OF THE PROPERTY.

In front of the Alleghany Mountain, which runs for a hundred miles in nearly a straight (N. E. and S. W.) line from Muncy to opposite Bedford, lies a long, narrow, straight, deep valley, about five miles wide, occupied by the West Branch Susquehanna, the Bald Eagle Creek, the Little Juniata, the south head of the Juniata River, and finally Dunning's Creek, which flows southwest and joins the Raystown Juniata at Bedford.

A geological cross-section of this valley, taken almost anywhere, is something like this:—Fig. 1.


← N.W.
Lowest coal bed
Conglomerate No XII.
Red Shale. No. XI.
White sandstone. No X
Red Sandstone. No IX
(Catts Kill)
(Chemung)
Olive Shales and muddy sandstones. No VIII.
(Portage)
Black slates often mistaken for Coal Measures. (Hamilton)
(Oriskany) Sandstone No VII.
(Helderberg) Limestone No VI.
Fossil Iron Ore beds in (Clinton) Red Shales. No V.
(Medina) White Sandstone. No IV
(Oneida)
Allegheny Mtn.
Dunning's Cr.
Dunnings Mt

The only notable variations from the above cross-section occur at three far distant points: 1. At Muncy, where the fossil ore flattens and sweeps round the end of the northeast end of the Bald Eagle Mountain; 2. At Frankstown and Hollidaysburg, where the fossil ore flattens and sweeps round the southwest end of Bald Eagle Mountain and the northeast end of Dunning's Mountain; 3. Here on your property; where, in a precisely similar style, the fossil ore beds, the red shales in which they lie embedded, the limestone formation (VI) over the red shale (V), and the Oriskany Sandstone (VII) all flatten and sweep in concentric semicircles round the southwest end of Dunning's Mountain.

I mean, of course, the southwest end of the straight part of Dunning's Mountain, extending from Hollidaysburg to St. Clairsville, about 20 miles; for the mountain opposite St. Clairsville, makes a right angle and runs east several miles, and then makes another right angle, and resumes its south-southwest course, past Bedford, into Maryland.

The fossil ore beds follow its flank.

Where the mountain runs its regular course the fossil ore beds are steep (nearly vertical) and their outcrops lie high up on the mountain side.

But where the mountain makes its offset to the eastward, the fossil-ore beds (and other formations) lie flat, dip south at gentle angles, and their outcrops are far removed from the base of the mountain.

Your property sweeps round with the ore beds; having them steep and on the mountain side at its north and northwest end,—having them flat and away from the mountain (on Black Oak Ridge) in its middle portion,—and having them again steep and up the mountain side, at its eastern and southern end.

Geographically, your property begins at St. Clairsville (its northwest end); extends three miles southward along the east slope of Black Oak Ridge; then half a mile eastward; and then three miles northeastward into Dutch Corner. Its St. Clairsville end is ten miles from Bedford; its Dutch Corner or southeast end, seven miles.

The proposed Bedford and Dunning's Creek R. R. would pass close to its southern boundary.

By this branch of the Huntingdon and Bedford line, its railroad distance from Huntingdon would be 57, and from Philadelphia 259 miles.

Should the B. & D. C. R. R. pass St. Clairsville and reach McKee's Gap (through Dunning's Mountain into Morrison's Cove) 17 miles north of St. Clairsville, the outlet of the property would be, via Altoona, to Pittsburgh also, and a shorter connection with Huntingdon and Philadelphia.

The accompanying colored lithograph map made from Mr. Platt's field notes, shows the courses and distances of Dunning's Mountain and the position of the ore beds on your land:

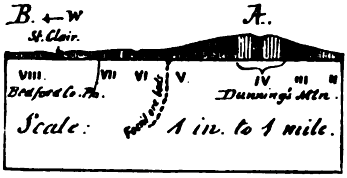
II. OUTCROPS OF FOSSIL ORE.

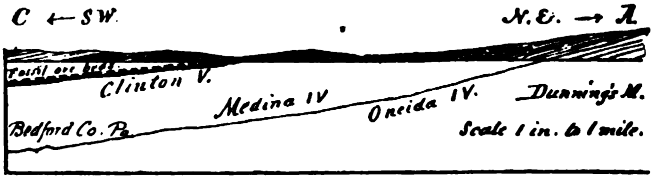
The descent of the outcrops from the mountain side to Weiset's Brook,—their run, along the east slope of Black Oak Ridge, past Kauffman's, towards Griffith's,—their run eastward and northeastward along the south side of the ridge, past Sill's and Walter's,—and their sweep round Dutch Corner, eastward, southeastward, and southward, towards Bedford,—appear on the map and need no verbal description.

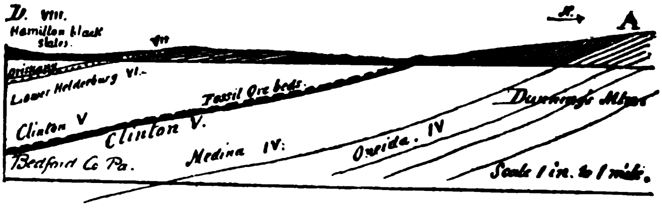
Three lines will be noticed on this map, diverging west, southwest, and southward, from a point A on the knob of Dunning's Mountain.

Three corresponding cross-sections, AB, AC, AD, show the geological structure along those lines, and the steepness or flatness of the ore beds.

Figs. 2, 3, 4. Reduced to a Scale of 2 miles the inch.







AB, Fig. 2, 8000 feet long, passes through St. Clairsville and a gap in Black Oak Ridge, and shows the formations IV, V, VI, VII, and black slates of VIII, all in a vertical posture.

AC, Fig. 3, 15,000 feet long, shows the formations IV, V, VI, and VII, flattened down, so as to spread the ore over the surface of the hill.

AD, Fig. 4, 15,000 feet long, shows the same formations, with the ore dipping at an angle of about 20°.

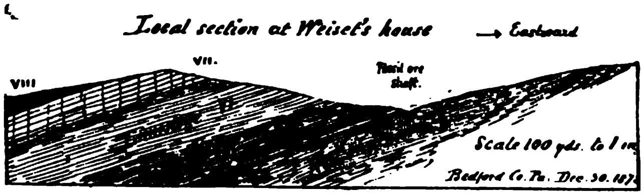
An indefinite number of such sections might be added, but these suffice.

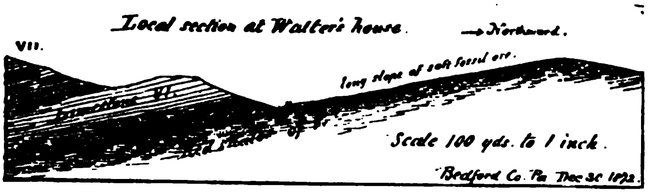
The only geological feature of importance not shown in the foregoing map and following sections is a small sharply pinched synclinal (trough) of limestone (VI) between Black Oak Ridge and the foot of the mountain south of St. Clairsville. This limestone basin is less than 150 yards across.

Black Oak Ridge is about 200 feet high above the brook at its foot. At its north end near St. Clairsville the Oriskany Sandstone VII forms its backbone; the black slates of VIII are there so much like coal-measure slates that the villagers of St. Clair explore them for coal beds, which of course do not exist.

At Weiset's house and southward the outcrop of the ore is at the bottom, or on the east slope of Black Oak Ridge. See local section, Fig. 5.

Figs. 5 and 6. Reduced to a Scale of 200 yds. to one inch.




Local section at Walter's house.
→ Northward.
VII.
Limestone VI.
long slope of soft fossil ore.
Scale 100 yds. to 1 inch.
Bedford Co. Pa Dec 30 1872.

From Griffith's house, eastward, the outcrop ore is on the summit of the ridge, and the bed spreads broadly down its gently sloping back. See local section, Fig. 6.

From Walter's house, northeastward, the outcrop slips down the north or front slope of the hill, facing the mountain, the hill top being about 150 feet above the brook.

The Limestone Ridge (capped with sandstone) runs round south of the ore ridge, and is twice as high (300 feet).

As the sections are drawn to scale (horizontal and vertical the same) they explain themselves, and I proceed to the description of the ore beds themselves.

III. THE FOSSIL ORE BEDS.

There are three ore beds in the red shale of V.

They lie so close together that they can be *quarried* together where the dip is gentle, as at Walter's.

But they lie so far apart that they cannot always be mined by one gangway where the dip is vertical or very steep.

The most northern openings on your property are 150 yards south of Weiset's house, and just above the brook level. Three shafts on the three beds. Upper and middle fallen in. Lower bed 12 inches of ore. Slates in roof and floor. Dip of ore N. 55° W.- 30° to 35°. General dip of formation -. 20° -. All three beds in 12 feet of shales.

Ore crop on the hill-top 600 yards east of Griffith's, dipping gently S. W. say 6°.

Ore crop on hill-top, 400 yards E. 20° N. of Sill's house; dip say 6°.

Ore crop on road at the foot of the hill, near the creek, 350 yards E. of Sill's house; dip say 5°.

Shaft on hill-top, midway between Sill's and Walter's; shows 41 inches of fossil ore in 12 feet of measures; dip say 5° to the south. See local section, Fig. 7.

On Walter's place, near the brook, this lowest bed has been mined for the furnace, 15 inches thick; very fine ore.

The *heaviest covering* Mr. Walter has found lying upon the *upper* bed of ore, *anywhere* on the slope from brook to hill-top between his farm and Griffith's, is 6 feet of olive slates. This is at the top of the hill up from the last named mining ground.

North of Walter's house, on the road, the following section gives 47 inches of ore, in 10 feet of space; dip say 4°-S. 70° East. See vertical section, Fig. 8.

FIG VII

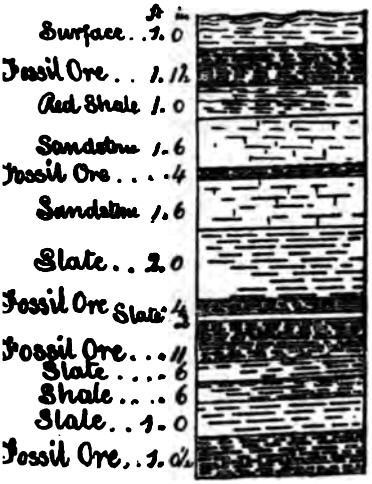


FIG 9

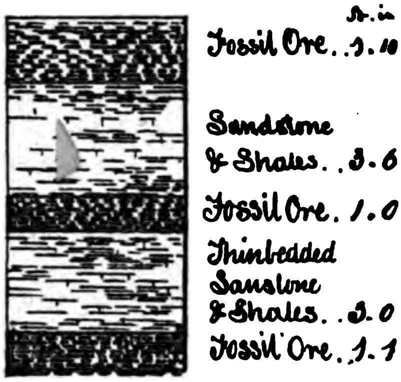

ft. in
Fossil Ore . . 1. 10
Sandstone & Shales . . 3. 6
Fossil Ore. 1. 0
Thinbedded Sanstone & Shales . . 3. 0
Fossil Ore . 1. 1

FIG 8

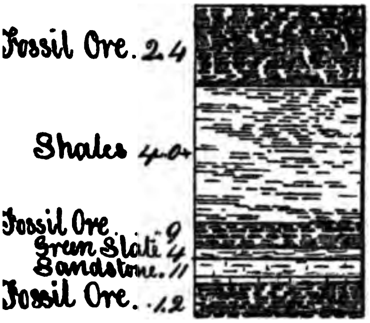


FIG 10

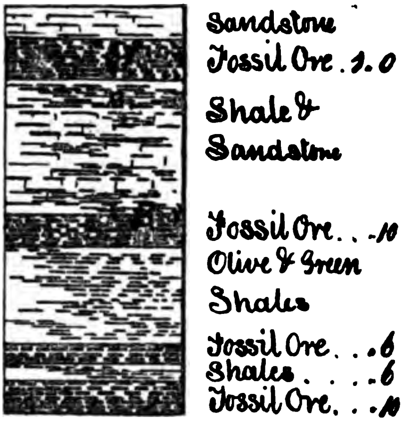
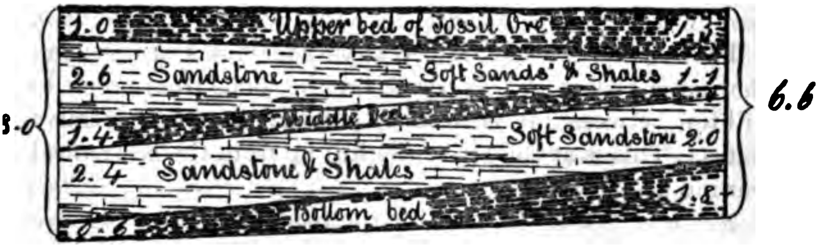


FIG 11



Kemble Iron Co Bedford Pa.

About 900 yards east of the road, and on the north side of the ridge, a shaft on the outcrop shows 47 inches of ore in 10½ feet of measures; dip say 8°-S. 50° East. Fig. 9.

About 500 yards east of the last exposure, and also on the north slope of the ridge, 80 feet below its crest, the ore dips S. 30° E.- 7° to 8°.

Here the ore crop leaves the ridge and strikes across to the mountain side.

At the northeast end of Dutch Corner the next section shows 38 inches of ore in 10½ feet of measures; dip of sandstone S. 30° W.-17°.

The *thickness of ore in each bed* varies with every rod of outcrop, as may be seen from the above vertical sections.

The *total thickness of ore in all three beds*, on the contrary, scarcely varies at all. In other words, you may confidently count on a total thickness of between *three* and *four feet* of the ore in from ten to twelve feet of measures. Secondly, you may count on always having at least one of the three beds of a good size. Thirdly, you can count on always mining two of the beds in one gangway.

You are always secure of at least *two feet* of good fossil ore, no matter where you strike the beds.

This regularity conjoined with irregularity is well illustrated in one of the two gangways of the Kemble Iron Company in the gap at Bedford. It inspires great confidence in the mining qualities of the formation all along Dunning's Mountain for twenty miles. The two connected sections, Fig. 11, were got in the north gangway, one at 400 yards in, and the other at 475 yards.

IV. QUALITY OF ORE.

The three beds seem to preserve their three individually distinct and different characters.

The top bed is a hard fossiliferous ore.

The middle bed is hard, and almost a limestone.

The bottom bed is soft, rich in iron, and holds but little lime. It looks (theoretically) as if it has always been the water-bearing stratum, and has suffered therefore so complete a washing out that all its original shells have disappeared and their places and forms been assumed by the oxide of iron. This however will be its state only to a certain depth below the present valley bottoms. It will then become a rocky calcareous ore, something like the middle bed. The same is true of it (and the other beds to a less extent) when mined down from the outcrop. They will lose in iron and gain in lime.

At Bloomsburg "soft ore" holding 85 per cent. perox. iron and only a trace of carbonate of lime, turned into "hard ore" holding 61 per cent. perox. iron and 33 per cent. carbonate of lime.

At Hopewell Furnace "soft ore" of 78 per cent. perox. iron and a trace of carbonate of lime, becomes a "hard ore" of 55 per cent. perox. iron and 31 per cent. carbonate of lime.

A multitude of analyses show the soft ore to range in its peroxide of iron between 30 and 75 per cent.

Where the dip is steep the breast of soft ore is of course short; where the dip is flat the breast of soft ore is very extensive: as between Griffith's and Walter's on your property, and so on into Dutch Corner. Where the bed spreads as a surface coating to a broad and gentle hillslope it is in its highest prime condition, both of richness and for cheap and abundant mining. It is here about a 50 per cent. ore; that is, it will allow of getting one ton of iron from two tons of ore, or practically two tons and a quarter.

Prof. H. D. Rogers, who made a careful, special study of this important subject at Danville and Bloomsburg, concluded that when the hillside sloped 15° and the ore beds dipped into it 30°, the softened part of the bed extended downwards about 40 yards, and he assumed this as the basis of his calculations of quantity.

Mr. Platt's calculations of quantity for your property take into consideration the flat lay of the ore in some places and its steep posture in others.

I. *From St. Clairsville to Griffith's; steep dip.*—(*a.*) From opposite St. Clairsville to Weiset's the outcrop descends the mountain slope 3,200 yards to water-level in the brook. Taking 40 yards as the depth of the soft ore, thickness (in 12 feet of measures) 40 inches (1 1-9 yard) of ore, and 2 tons to the cubic yard, we have 280,000 tons of soft ore; say one-half of this lies *above* brook water-level.

(*b.*) *From Weiset's to Griffith's; dip growing less steep.*—Outcrop always from 25 to 35 feet above brook level, on east side of Black Oak Ridge, 1,900 yards. Soft ore say 50 yards down; tons 210,000; mostly below brook water-level.

II. *From Griffith's to* (*shaft* 100 *yards east of road north of*) *Walter's; dip almost horizontal.*—Top ore bed scarcely 3 or 4 feet under surface anywhere; ore beds thoroughly softened and enriched by dissolution of the shells; lowest bed *very* rich; distance 1,500 yards; breadth from brook up to hill-top 200 yards; total amount of soft ore above brook to be got by stripping, 400,000 tons; total of ore to be got by stripping or otherwise, 660,000 tons.

Note: the deduction 660,000 to 400,000 is based on the fact that towards the bottom of the slope the covering shales get to be 10 or 12 feet thick (as in the old cellar opposite Walter's house), and may be equally thick in other places. This will interfere only with the open quarry work, but not with underground mining.

(*b.*) South of the brook the beds descend beneath the country very flat and are softened doubtless to a great distance downward. If we assume 300 yards, we have thus, beneath water-level, one million (1,000,000) tons of soft ore.

III. *From Walter's eastward.*

(*a.*) For the first 1,300 yards, northeastward. At 800 yards the crop has got down 25 feet below the crest of the ridge on its north face; at 1,300 yards 100 feet. Most of the distance the covering rocks allow the complete softening of the beds. Mining from the brook by a short tunnel (northward). Breast of say 200 yards. Total of soft ore, 580,000 tons.

Below brook water-level (in the other direction, southwards and downwards) another 580,000 tons of soft ore, or even a larger quantity, is available.

(*b.*) Along the crop, in the curving valley-bottom of the (northern) brook (north of the ridge and against the mountain), 2,800 yards to the end of Dutch Corner. Ore all below water-level. Dip steep towards the east end. Extent ot softening say 40 yards down. Total of soft ore, 250,000 tons.

SUMMARY OF QUANTITY.

Soft ore above water-level, one million one hundred and twenty thousand tons	1,120,000
Soft ore below water-level, one million six hundred thousand tons . . . . , . .	1,600,000
Soft ore parts of the bed only	2,720,000

I consider it unnecessary to calculate the quantities of harder ore in the undecomposed parts of the beds, amounting to millions of tons, for these will remain as a reserve for the future. The regularity of this ore formation enables me to assert that there lie six million (6,000,000) tons of ore, more or less, under every square mile of the district, where the dip is gentle.

I have left out of consideration of quantity for the present also the ten miles of vertical beds from Dutch Corner to Bedford, and the vertical run of the beds for some miles north of St. Clairsville along the west side of Dunning's Mountain, towards Sarah Furnace, on the way to McKee's Gap.

A railway line up Dunning's Creek from Bedford to Hollidaysburg (or McKee's Gap) will bring into play this long outcrop-(north of St. Clairsville), and I have no doubt that mining operations will be successful at certain points along the outcrop.

N. B.—It is my duty to call your attention to the ore bed *at the bottom of the red shale formation of No.* V, the outcrop of which ought to be found still higher up the slope of Dunning Mountain, close to the uppermost stratum of the White Sandrocks of No. IV. Between Marklesburg and Saxton this bed (part rock ore and part soft fossil) is more than 20 feet thick, and is mined, yielding from 2 to 6 feet of soft ore. I advise that careful search be made for it on Dunning's Mountain.

Appended you will find Mr. Harden's statement of mining methods and costs, which I append to my report as sure to be of great value to you in your future operations.

I am sir,
Very respectfully yours, &c.,
J. P. LESLEY.

1008 Clinton Street, Philadelphia.
DEC. 30, 1872.

To Professor J. P. Lesley:

SIR:—A question as to the precise method one would adopt in the mining of any condition of mineral, is not answered in the character of the mineral itself, even where it forms the whole or the greater part of the bulk to be mined, much less in the case where that for which the mining is made, forms so small a portion of it; but in the character of the superincumbent and associated strata taken as a whole.

The ores of Dunning's Mountain and of the valley of Dunning's Creek, the subject of this paper, are a continuation southwest of the same at Hollidaysburg, forming deep claret-colored bands of insignificant thickness, compared with the several hundred feet of the many colored calcareous shales, slates and beds of sandstone, of which the accompanying measures are made up, and of which they form a part, cropping to the surface in many places both in the valley and on the mountain's slope, the line of outcrop varying in both range and altitude, directed in the one by the flexuous course of the mountain and low associating ridges, and in the other, by their protection or exposure to the action of denuding forces.

That portion of the outcropping line here treated of, extends from St. Clairsville, north, to Bedford, south, a distance, measured by it, of about 15 miles, and consists of three beds of ore lying within a space of from 8 to 12 feet, interstratified with red shale, brownish and greenish soft clay slate, and thin bedded sandstone, the under and overlying measures being of a similar character, and varying in their dip from an angle with the horizon of 4° to 5° in and about the middle of the line, to that of 70° or 80° at either end, St. Clairsville and Bedford.

In the several sections of the measures taken at the various openings and points of exposure as given in the aforegone report, we have conditions exceptionally favorable to the working of the less inclined portions of the belt, by open quarrying, and a personal examination made of the two tunnel openings of the Kemble Iron Company at Bedford Gap discovered nothing to me likely to conduce to an unfavorable condition for the mining of the more highly inclined and heavier covered portions of it. On the contrary, a somewhat extended practice in the mining of such like measures leads me to the conclusion, that, in the exercise of the skill necessary to all such work, the mining of these ores will not be productive of more than the average of ordinary contingency, and as compared with the mining of the unstratified ores, will certainly be less, the cost of production also bearing relation thereto; always providing that the ores maintain their aggregate thickness and their average distance one of the other. And since the sections exhibited were taken at points extending over an area of several miles, we are not led to expect a greater variableness than they represent, and this leads us to quantity.

Hand specimens of the ore brought away gave a specific gravity of 2,818, a little more than that of the sandstone by which it is accompanied. This gives 175.62 lbs per cube foot or 12.75 cubic feet to the ton.

From these data the production of ore will be 284 tons per inch per acre; which multiply by the number of inches thick in any given section and we have the total in tons per acre of the locality to which the section applies. Average the whole, say at 36 inches, and we get 10,224 tons per acre over the area covered.

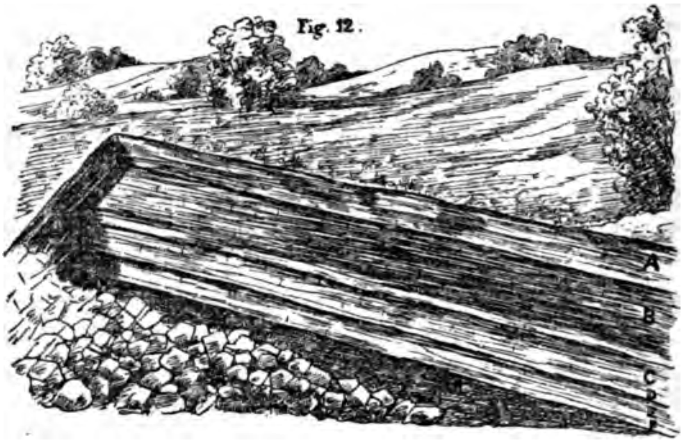
A conversation which took place at Bedford on this part of the subject has led me into closer detail than otherwise would have appeared necessary.

Presuming that those localities holding the beds easiest to be gotten, will be the first to be attacked, a word on open quarrying will not be out of place. Stripping the ore then, that is, taking off the surface covering, will necessarily be the first operation, and in doing this do not dump the dirt where it is likely to be in the way of future operations. It is not a needless warning, this. There is not an opening with which I am acquainted, unless lately made, that is not suffering more or less by being hampered up with old stripping, and where, in more than one instance, it has not had to be moved a second time.

Mr. Walters says that the greatest depth of covering on his farm, and at the explorations made in the neighborhood of it, is 6 feet to the top band of ore. To aid in my illustration call it 6 feet; add the 10 or 12 feet of measures to the bottom of the lower band, as represented in the section taken north of his house, and again in Dutch Corner, and we have a total depth of 17 feet. In the working of this, I would recommend a length of bank-face to be set out, limited only by boundary lines, deviations in level, or quantity to be supplied, and that this face be quarried in widths, strip after strip from end to end, advancing up hill as rapidly as dictated by the demand, dumping the stripping and quarried refuse on to the cleared out ground, only taking care to dump it far enough away that the work to be done along the bank-face may not be stifled.

But as there should be some adherence to uniformity in the doing of this, we have to seek the width of strip best adapted to the result aimed at, and as under certain conditions I would recommend the use of gunpowder, the line of least resistance in the use of it, will suggest and fix that width; and as it is a heaving *in mass* that is contemplated, and not a blowing to pieces, the shots would be put to the bottom of the lowest band of ore. Eleven feet then would be the length of the line of least resistance, the width of strip taken at one time therefore should not be less. The sketch below, made from a section taken on Walter's farm and showing the three bands of ore, will help to convey the intention.

Fig. 12.



SKETCH OF BANK-FACE WITH THE STRIPPING OFF TO THE FIRST BAND OF ORE.

A. Face of stripping, 6 feet thick.
B. Surface of Top Band of Ore, 11 feet width of Strip, 24 inches thick.
C. Interval of Shales and Sandstone, 42 inches.
D. Middle Band of Ore, 12 inches.
E. Interval of Shales and Sandstones, 36 inches.
F. Bottom Band of Ore, 13 inches.

Depth of Ore face with 2 intervals, 10 feet 7 inches, include Stripping, 16 feet 7 inches.

But as the ore to be taken out constitutes in bulk only a fourth of that to be quarried, and as when loose the refuse will occupy one and a half times the space it did in the solid, it follows that the refuse heap will increase beyond the limits of the area quarried; this, however, is provided for in the rise of the hill as the work advances. Retaining walls will also be needed, from which to dump the ore into the railroad cars; these will be made of posts and planks backed up with the refuse.

The lay of the measures as a whole, and their individual structure, are each of a character favorable to such a mode of procedure. The jointed condition of the sandstone, when not in thin plates, will allow the free use of the crow-bar to advantage, but the shales operated on from above, that is, perpendicular to their bedding, will be tough to the pick-axe; holed under, or worked at on the face will give the best result.

While it may not be absolutely necessary to resort to blasting, a judicious use of gunpowder will be of infinite advantage; a series of holes put down to the bottom of the ore, or to the bottom of the lower interval, at a foot from the face of stripping, and loaded so as to loosen the mass only, would make easier work for the crow-bar and pick-axe, and would not make the ore any the less easy of separation from the refuse. Each quarryman has generally his own notion of the quantity of powder to be used in a given case, seldom deduced from any fixed data. Practice has shown that the quantity must be increased as the cube of the mass to be blasted, from which it is laid down that the cube of the line of least resistance in feet, divided by two, equals the necessary quantity in ounces; less, however, will answer the purpose here; well directed experiment at the beginning, guided by this rule, will be of profit.

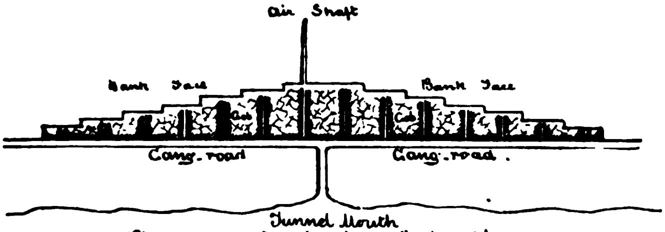
In estimating the cost of quarrying these ore beds, we have tolerably well-defined data in the ores and intervening strata, but a fluctuating element in the amount of covering; taking, however, as an example the section before given, I am of opinion that at the present rate of wages, the ore may be put into cars on the quarry for—in other words, that the cost of production will be—one dollar twenty-five cents per ton ($1.25). With a less thickness of ore or increased covering, I need hardly say the cost of production will be increased; 36 inches of ore, the average estimated, with the same amount of covering, will cost one dollar fifty-four cents ($1.54). The covering is, however, in some places much less.

In the more highly inclined and heavier covered beds, we have conditions which render mining necessary, and the method I would adopt, would be that which, in coal and the clay ironstone bands, is called Longwall; for whether mined in shorter or longer "banks," called by some "stoops," the same principle prevails, namely, that of mining out the whole of the mineral, packing the refuse, which is called gob or goaf, in the space mined, and putting out the ore either by shoots or cars, agreeable to the angle of inclination at which the measures lie.

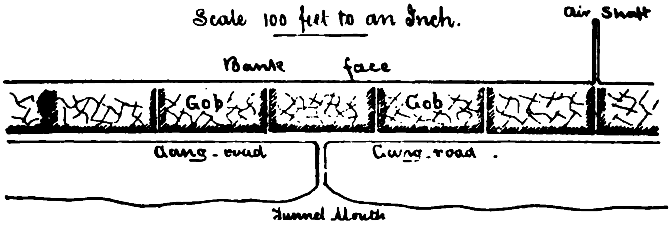
With such inclinations then, as wherein cars cannot be made use of in the gob-roads, a drift (tunnel) will be put in above water-level, and along the strike of the ore, of sufficient capacity for the running of cars, say 7 feet wide at the floor, battering inward to 5 feet at the roof, and 6 feet or 6 ft. 6 in. high, regulated by the height of the cars used; a shoot by which to deliver the ore into them having to be provided for. This will be the gang road, and should have a series of "bolt holes" (places of refuge) cut for men to escape in, when traveling it and meeting the cars, and it will be necessary to well timber this road, the dimensions given being those clear of the timbers. On the rise side an opening head will be made parallel and immediately contiguous to it, both being extended just so far as it is intended to work the ore, it may be 1,000 or any number of feet, regulated by the nature and the local uniformity of the measures, and the limit of economy in haulage and ventilation. The mouth of the gang road may either be at one end of the work, or it may be in the centre of it, receiving cars from right and left.

The opening head, as it is driven, will be divided into "banks" of say 35 or 40 feet long on the face, which banks will be mined to the rise, the ore being put down a road left in the centre, by the gob being built up on either side, and supporting the roof, as shown in the diagram below. Ventilation being provided for by staples (small shafts) being sunk from the surface, or by drifts put up in the ore; when that does not crop out on the surface, both will be needed.

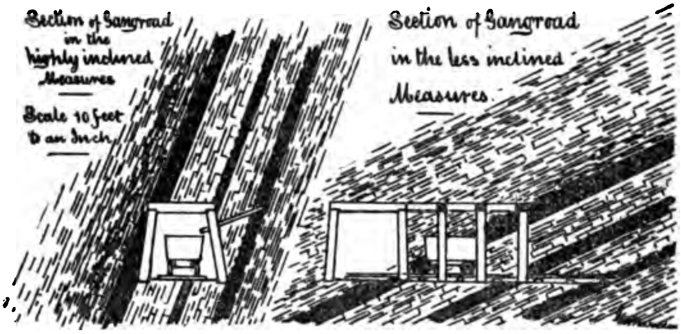
Fig. 13.



Plan for working the highly inclined beds



Plan for working the less inclined beds.


Section of Gangroad in the highly inclined Measures
Scale 10 feet to an Inch
Section of Gangroad in the less inclined Measures.

With dips of less inclination, wider banks may be worked, the ore being run to the gang road by self-acting inclines.

While it is not easy to define beforehand with preciseness, what will be the action of any group of strata, the foregoing is a general description of the methods I believe best to be adopted in the mining of these ores. There will of necessity be contingent matter present itself, which can only be dealt with as it arises, but in the hands of a skillful and careful manager, I know of nothing likely to lead to unfavorable results, and I am of opinion that, the ores maintaining their thickness, will be mined and put into Railroad cars at the mouth of the mine for two dollars and twenty-five cents ($2.25) per ton.

I am sir,
Respectfully yours,
J. W. HARDEN,
Mining Engineer.

2823 Girard Avenue,
Philadelphia, Jan. 2, 1873.

M'Calla & Stavely, Printers, 237-9 Dock St.
1871.

THE

TITANIFEROUS

IRON ORE RANGE

OF

NORTH CAROLINA.

REPORT OF

J. P. LESLEY, GEOLOGIST.

PHILADELPHIA:
M'CALLA & STAVELY, PRINTERS, 237-9 DOCK ST.
1871.

THE PROPERTY

OF THE

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CENTRE IRON

AND MANUFACTURING CO.,

OF PHILADELPHIA.

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THOS. J. HOUSTON,	*Millerton, N. Y.*
NATH. ELLMAKER, JR.,	*Lancaster Co., Pa.*

The Tuscarora Iron Ore Belt

IN NORTH CAROLINA.

GEOLOGICAL REPORT BY J. P. LESLEY.

Philadelphia, March, 1871.

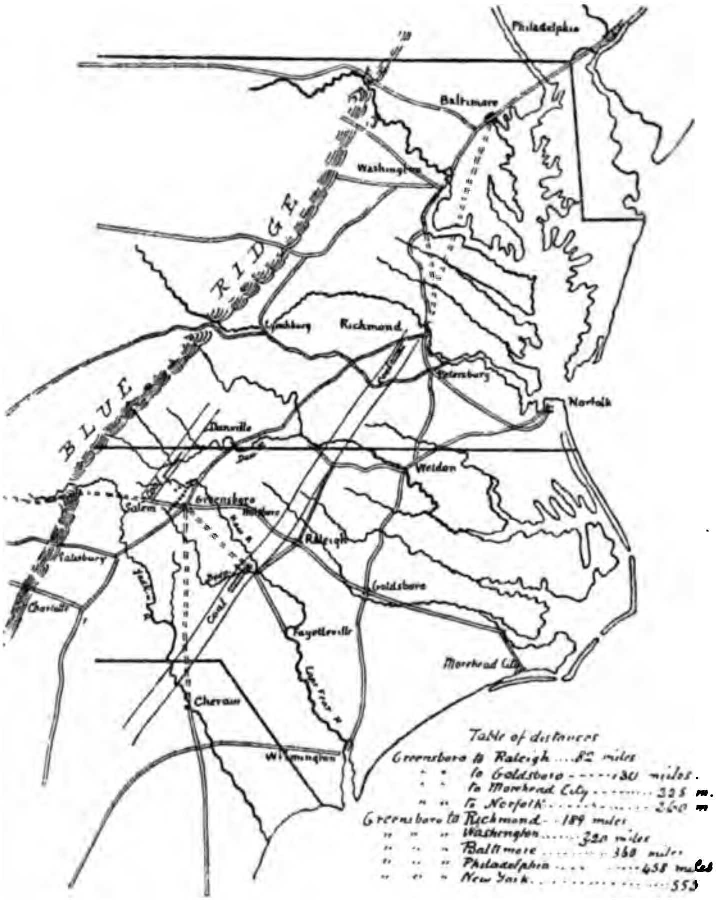
To Thomas Graham,

President of the N. C. Central Iron Company.

Sir: Accompanying this report, you will find a map which I caused to be made, to show the course of the iron-ore-bearing formation through the plantations which you own, or control, in Guilford and Rockingham counties. On this map one or more of the bounding lines of each plantation is laid down, where such boundary lines cross the ore-belt. The Tuscarora Forge property is plotted out; and the relative positions of Superintendent's house, store, forge, ore openings, and main roads are given with sufficient accuracy. The geographical relation which Greensboro, the county town of Guilford, holds to the Forge, is shown; and the general direction taken by the Dansville and Greensboro, and by the Greensboro and Salem Railroads,—the latter crossing the ore belt, and the former running somewhat parallel with it, but approaching within a mile of it at its northern end, north of the Haw river.

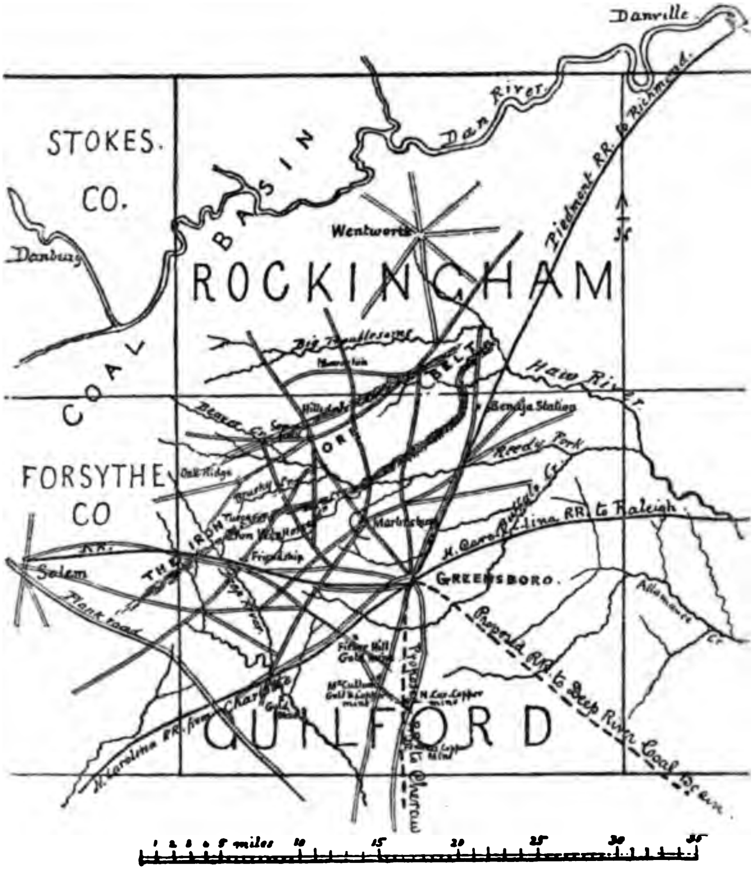
The following sketch-map (fig. 1), however, is necessary for giving a general idea of the country through which your ore-belt runs, preliminary to a more precise statement of its structure, and economic value :

FIG. 1.


Philadelphia
Baltimore
Washington
BLUE RIDGE
Lynchburg
Richmond
Petersburg
Norfolk
Danville
Dan
Weldon
Greensboro
Salem
Raleigh
Salisbury
Charlotte
Goldsboro
Fayetteville
Coal
Morehead City
Cheraw
Cape Fear R
Wilmington
Table of distances
Greensboro to Raleigh ....82 miles
" " to Goldsboro ------130 miles.
" " to Morehead City ....225 m.
" " to Norfolk ....260 m
Greensboro to Richmond - - 189 miles
" " " Washington ....320 miles
" " " Baltimore ....360 miles
" " " Philadelphia ....458 miles
" " " New York...........................553

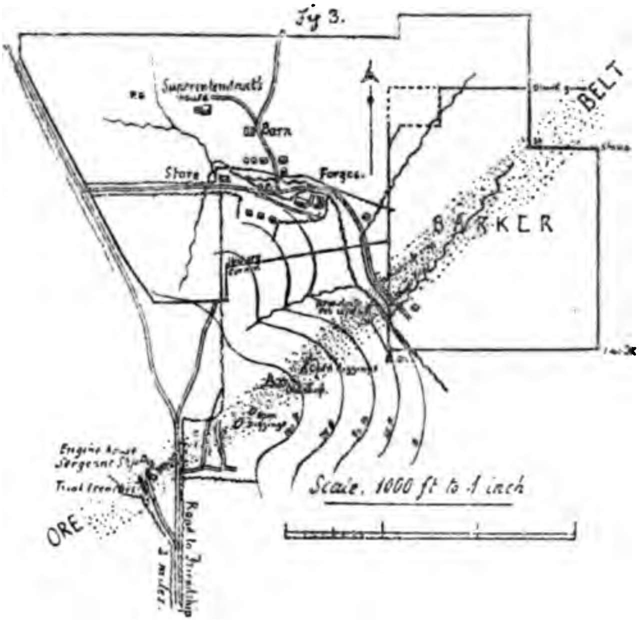
The following sketch-map [fig. 2], on a larger scale, will suffice to point out more distinctly the local relations of the iron works and ore-belt to the railroads radiating from Greensboro:

Fig. 2.

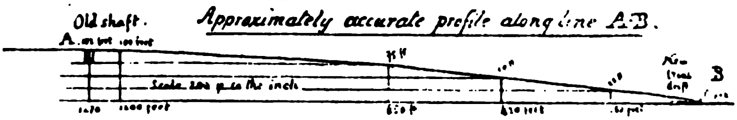


The following [fig. 3,] is a plotting of the Company's Forge Property, from the title deed. On this I have plotted the appurtenances, houses, store, forges, shafts, and diggings—with sufficient accuracy:

Fig 3.



Approximately accurate profile along line A B.



From this profile, obtained with a Locke level and pacing, I have drawn in contour-level-lines, upon the sketch-map of the property above, to show the general character of the hills and vales along all other portions of the ore-belt.

On the two following pages [fig. 4 and fig. 5], I have repeated the general map of the ore-belt, 28 miles long [in a straight line], on a reduced scale of one mile to 4-5 [four-fifths] of an inch, for the convenience of reference in this report. Most of the names of the properties were obtained while making the survey. The rest are taken from the memorandum of leases, &c., which it is needless here to reproduce.

A scale of miles is drawn alongside of the ore-belt, for convenience of measurement. As I could not conveniently number the properties in order, and as the names are so numerous, and some are repeated in different farms, I shall use the scale of miles to indicate the locality of any lease or plantation on which I shall wish to describe particularly the situation or character of the ore; for example—Widow Dickey [17-18], &c. The miles commence at the extreme southwest limit of the properties, at a branch of Deep river, a mile or so northeast of the plank road. The forges are reached at the 9-10th mile-marks; the forks of Reedy at the 16th, Benaja station at the 25th, and Haw river, and Vaugh's & Jones's end of the ore-belt at the 28th.

Messrs. Platt and Frazer, during their survey, made estimates of the length of the ore-belt crossing each plantation. It is hardly worth while to give the list and column of figures, seeing that any one can measure the length, on each plantation, on the map, by means of the scale of miles; the whole length being [in the Tuscarora ore-belt] about 1760x30—52,800 yards. The table will, however, show what different lengths of run, across different plantations, the ore must have, owing to the direction taken by the land lines, most of which are, indeed, north and south lines; but many others run at angles to this, more or less acute.

Christ. Teague	2000	yards.
Susan Teague	500	"
Wm. Hitchcock	670	"
Keziah Swaim	570	"
Ezechial Hitchcock	247	"
Martin York	400	"
Geo. Bodenheimer	640	"
Wm. Idol	nearly 400	"
Wm. Willburn	1100	"
D. Davis	600	"
And. Idol	200	"
Elisha Charles	200	"
Andrew Gamble	1300	"
Jos. Davis	880	"
Clarke	480	"
Widow Cooke	570	"
Mary Chitman	1000	"
Lindsay	350	"
Raper	1140	"
Clark	500	"

FIG. 4.

NORTHERN HALF OF THE ORE BELT.

(*Reduced by Photolithography.*)

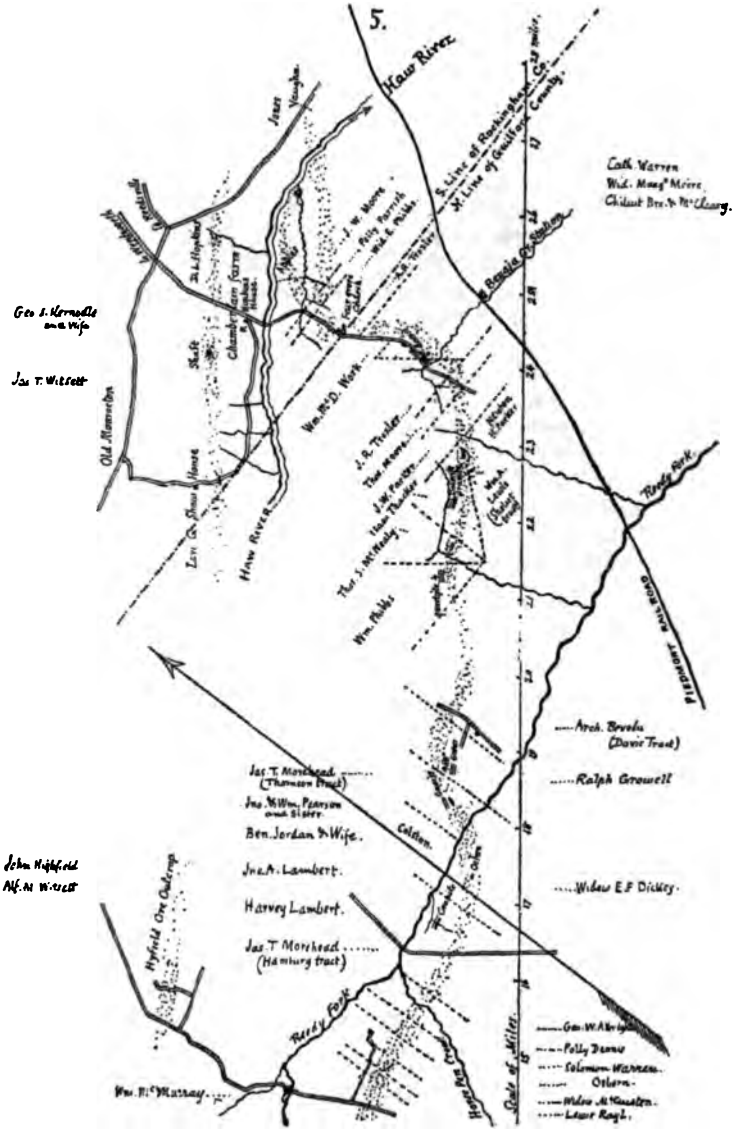
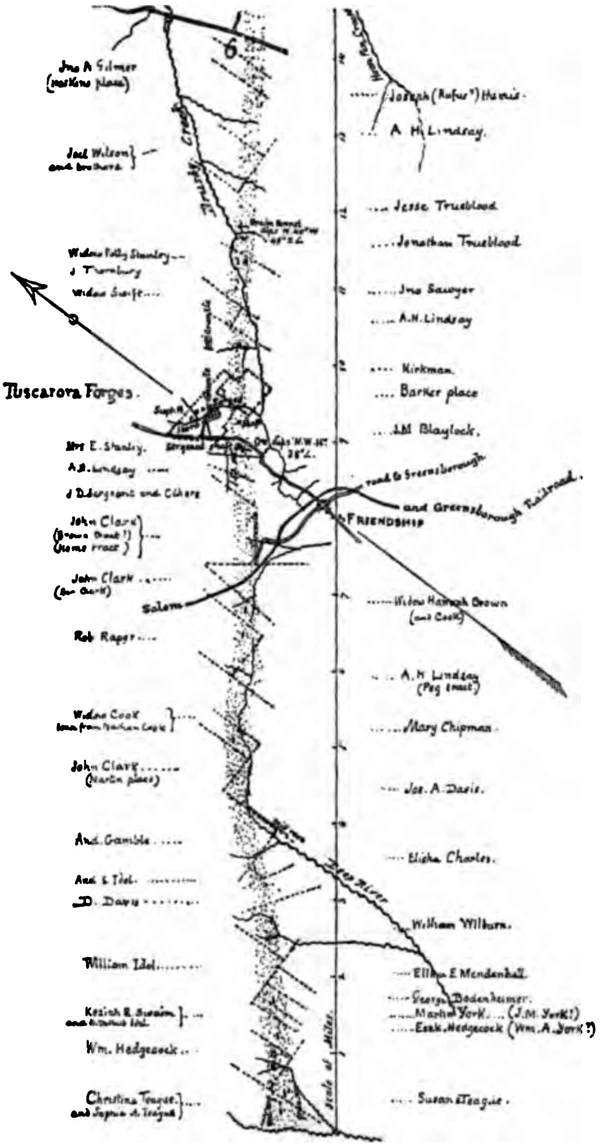


FIG. 5.

SOUTHERN HALF OF THE ORE BELT.

(*Reduced by Photolithography.*)



Cook and Wid. Brown	670	yards.
Clarke (Home Tr.)	1600	“
Lindsay	500	“
Stanley	850	“
Blaylock	670	“
Company Lands	620	“
Kirkman	1200	“
Lindsay	680	“
Mrs. Swift	short	“
Wid. Stanley	860	“
Sawyers	250 to 500	“
Trueblood	1540	“
Joel Wilson	900	“
H. Lindsay	1360	“
Rufus Harris	480	“
Wm. McMurray	——	“
Mrs. McChristian	265	“
Cal. Osborn	300	“
Sol. Warren	600	“
Polly Dennis	540	“
Geo. Albright	725	“
Jas. Morehead (People's place)	2100	“
Widow Dickey	920	“
Colston	extreme corner.	
J. Morehead (Thompson)	950	yards.
Gorrell	1110 to 1200	“
Davis	boundary not fixed.	
Wm. Phibbs	“ “ “	
Thos. McKneely	700	yards.
Thacker	1600	“
W. A. Lewis (Shelcot)	corner	
Parker	800	“
Thos. Moore	420	“
J. R. Troxler [Here the belt bends]	600 ?	“
Jas. Grant	1600 ?	“
A. R. Troxler	346 ?	“
McWork	—	“
Widow Phibbs	—	“

No special estimate was made of the run of ore on the properties crossed by the Highfield or Shaw-Alcorn ore-belt.

Note.—The centre line of the belt was the line of measurement.

Note.—All the above figures stand subject to correction, when proper surveys shall be made of the several plantations.

GENERAL GEOLOGICAL DESCRIPTION.

This part of North Carolina is occupied by some of the oldest rocks known; the same rocks which hold the iron ore-beds of Harford Co., Md., and Chester Co., Pa., and the gold ores of Georgia, North Carolina, Virginia, and Canada. The gold mines of Guilford Co., N. C., are opened alongside of, and not more than ten or twelve miles distant from, the Tuscarora iron ore-belt. [See map, on page 9, above.] Both the gold and iron range continuously (with one break, in New Jersey,) all the way from Quebec, in Canada, to Montgomery, in Alabama. The gold and iron-bearing rocks are: granites, gneissoid sandstones, and mica slates, all very much weathered and decomposed; and that to a depth of many fathoms beneath the present surface. The solid granites are decomposed least; the mica slates most. All contain iron, which has been peroxidised and hydrated, in the process of decomposition of the whole formation, and dyes the country soil with a deep red tint. Or, more properly speaking, the surface of the whole country is streaked with belts of red and gray soil, following the outcrops of the more weathered and the less weathered beds. But, even in the gray belts, the solid granite, or gneiss, or sand-rock, seldom appears at the surface, although outcrops of them can here and there be found; and a number of these outcrops are designated upon the map, close to, and on each side of, the Tuscarora ore-belt outcrop. The surface of the country, therefore, is a smooth, soft, undulating plain, broken by gentle vales, the bottoms of which are never more than one hundred feet below the plain, and commonly not more than half that depth. The roads show how readily the rock soil absorbs water and dries off again. The soft, mouldered condition of all the rock strata, to depths of 50 or 100 feet, is therefore easily understood. But the rapidity with which the erosion of the land goes on is surprising. An old bridge, built a century ago, over a stream near the Quaker Meeting House, and of course several feet above the water, is now buried to a depth of 6 feet beneath the surface of the little meadow.

Two general results follow this universal ancient rainwater decomposition of the surface of the country, to the depth of the deep valley drainage plane:—

1. All sulphur, &c., has been washed out of the ore-beds, leaving the ore remarkably pure. Whether the ore-beds, when followed down for hundreds of feet or yards into the earth, will be found to keep a notable percentage of sulphur, cannot now be known. But, whatever sulphur was originally combined with the iron, has been removed from the upper parts of the beds.

2. The decomposition of the rock strata, which inclose the ore-beds, has weakened them so that extra care must be bestowed upon all shafts and tunnels sunk or driven to win the ore, to keep them safe for mining operations. When the more solid strata, at various depths beneath the surface, are reached, mining operations will be as simple and safe as in any other region.

The hills being never more than about one hundred feet above the valley-bottoms, the ore-beds can be *mined by horizontal self-draining adits*, or tunnels, only at well selected points. But, seeing that the ore-beds run in straight lines for long distances, a large quantity of ore can be thus taken out, for some years to come.

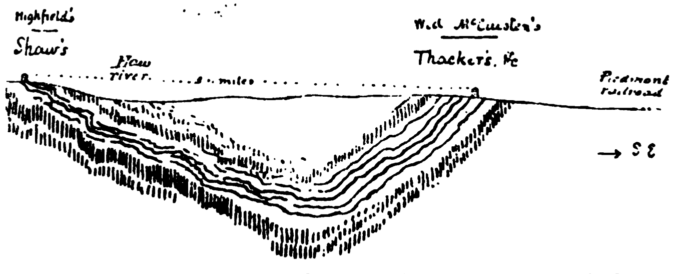
As the ore-beds dip at an angle of 45°, and at other angles to the horizon, *mining by shafts* [of two and three hundred feet in depth, sunk to strike the beds, with breastings of three to five hundred feet,) is an easy matter at all points where tunnels cannot be driven directly into the beds. And, although the porous nature of the surface country will also send down a larger quantity of water into the mine than usual, yet attention to keeping the actual surface smooth and free from holes and pits, and care to procure sufficiently powerful pumps at the outset, together with care to strike the beds at a considerable depth below the horizon of decomposition, will suffice to prevent more than about 25 cents a ton being added to the ordinary expenses of mining by tunnel at water-level.

These general statements apply uniformly to the range of plantations, owned or leased by the Company, nearly thirty miles in length.

The belt of outcrop of ore-bearing rocks has a uniform breadth of several hundred yards, and, I believe, a uniform dip towards the northwest, or north-northwest; although there are appearances (to be stated in detail hereafter) which would lead many persons to conclude that the outcrop was double, and not single; that is, that the belt is synclinal, the ore-beds descending from the southeast side, downwards, northwestward to a certain depth, and then rising again to the surface. But the general considerations against this view are so strong, that I reject it without much hesitation; and I give my reasons further on in this report.

The map, however, shows *another ore belt* running nearly parallel with the *Tuscarora Forge Outcrop*, and at a distance of three miles from it. This is called the Highfield, or Shaw Outcrop. Beyond the Haw River these two belts approach each other, and are believed to unite in Rockingham County. This, and other considerations, make it almost certain that the Shaw belt is the *Northwest outcrop* of a synclinal basin, three miles wide, and that the Tuscarora Belt is the *Southeast outcrop*. If so, the Tuscarora Orebeds descend with a N. W. dip to a depth of a mile beneath the surface, and then rise again as the Orebeds at Highfield and Shaw's; thus:

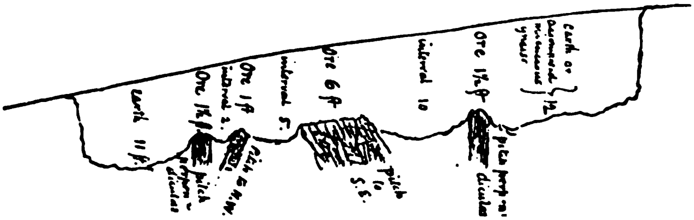
FIG. 6.



Many of the outcropping ore-beds are to all appearance, vertical; others dip irregularly, some Southeast, others Northwest; some steeply, others gently. But all these are extremely local variations, confined to a few feet or yards of depth, and will not invalidate the general uniformity of Northwest dip of the whole Tuscarora Belt, and Southeast dip of the whole Shaw Belt.

The following section of beds on (fig. 7) the Widow McCuisten plantation (14—15 miles), in a trench cut at right angles to the outcrop, 50 feet long, and from 4 to 8 feet deep, will illustrate these irregularities :—

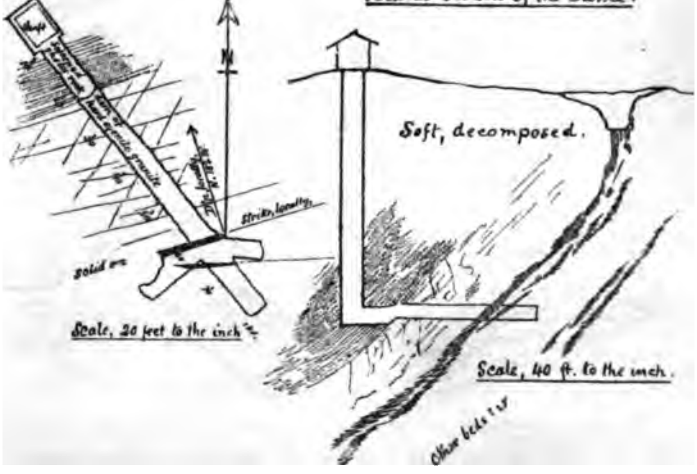
FIG. 7.



Similar irregularities are noticeable everywhere. The miners say that the pitch of the outcrop of the ore-bed worked in the Sergeant Tunnel and Shaft (9) was Southeast for some distance down, after which it took its regular Northwest dip, such as it now has in the shaft and tunnel at a depth of 100 feet. Besides which, there are in fact two beds cut in this shaft-tunnel, the smaller bed underlying the other, and with a dip which would carry the two beds together at some distance beneath the floor. See plan and section of the Sergeant Shaft and Tunnel below :

Fig. 8 Ground plan of the Sargeant Shaft and Tunnel.

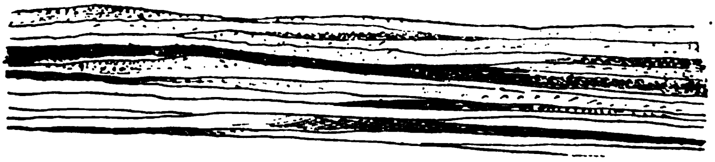
Vertical Section of the Same.



These examples lead me to the principal topics of interest in this report; 1, the number; 2, the size; and 3, the quality of the ore-beds.

They are ore-beds, not ore-veins; for they do not cut through the rocks crosswise. They have no well defined walls; they have no selvages; there is no gangue-rock different from the rocks on each side; they have, therefore, not been formed in crevices subsequently in a later age after the uptilting of the formation; they have neither been ejected volcanically from below, nor infiltrated aqueously from above, nor secreted chemically from the wall rocks; in a word they are not at all "veins." On the contrary they are "beds;" beds deposited like the rest of the rocks in water; deposited in the same age with the rocks which hold them; are in fact rock-deposites highly charged with iron; and they differ from the rest of the rocks of the formation in no respect, excepting this: that they are *more highly charged with iron.* I can best represent the facts of the case by an ideal diagram of the rocks of the ore-belt in their original horizontal position, somewhat thus:

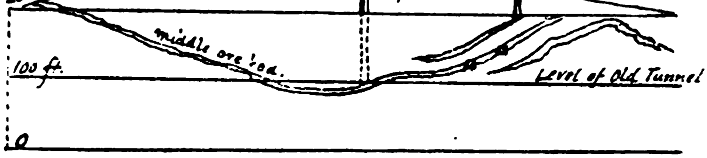
FIG. 9.



In fact all our primary (magnetic and other) iron-ore beds obey this law. They are merely certain strata consisting more or less completely of peroxide of iron, with more or less intermixture of mud and sand, which, when crystalized, fell into the shape of feldspar, hornblende, mica, quartz, etc., etc.

To show that this is not mere theory, but actual fact, I compare here the section of magnetic iron-ore beds *worked out* on Durham Creek, near Easton, Pennsylvania, a map and sections of which can be seen by reference to W. Brook's part of the New Jersey Geological Report, by Prof. Cook, 1868, page 332 [fig. 10]. It follows, then,

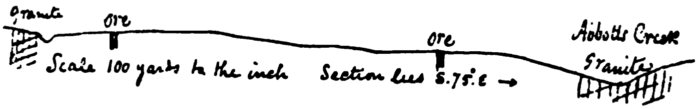
FIG. 10.



1. That *the Number of ore-beds* in such a formation cannot be stated. A large number of rock strata will become ore-beds *locally.* But

there will always be a particular part of the formation more generally and extensively charged with great quantities (or a high percentage) of iron than the rest. In other words, the iron of the formation as a whole is concentrated along one or more lines. This is evidently the case with the Tuscarora Ore Belt, as is shown by the almost perfect straightness of the outcrop of the Sergeant Shaft ore-bed, where its outcrop has been opened for half a mile northeast of the shaft. There are two principal beds cropping out on the Teague plantation, at the (southwest end of the belt), both vertical, and about 300 yards asunder, thus :

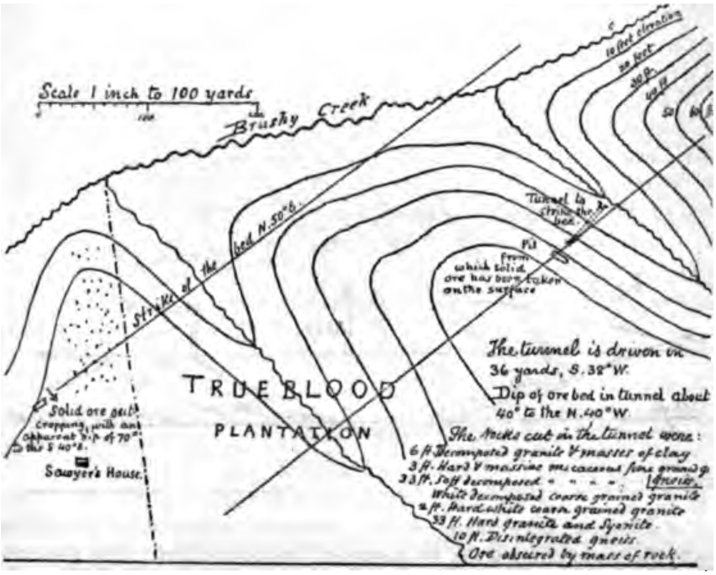
FIG. 11.



Another instance occurs on the Trueblood plantation (12 miles), where the two ore-beds appear to be only about 200 yards apart at their outcrops, and seem to dip different ways, which I explain by reference to the false surface-dip of the Sergeant Shaft bed. The Trueblood section is as follows:

FIG. 12.

Plan of the outcrops and diggings on the Trueblood Plantation

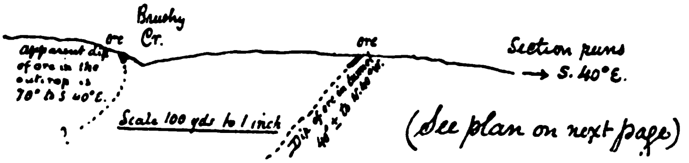

Scale 1 inch to 100 yards
0
100
200
Brushy Creek
10 feet elevation
20 feet
30 ft.
40 ft.
50
60
Strike of the bed N.50°E.
Tunnel to strike the bed.
Pit from which solid ore has been taken on the surface
TRUEBLOOD
PLANTATION
Solid ore out cropping, with an apparent dip of 70° to the S 40°E.
Sawyer's House.

The tunnel is driven in 36 yards, S.38°W.

Dip of ore bed in tunnel about 40° to the N.40°W.

The rocks cut in the tunnel were:
6 ft. Decomposed granite & masses of clay
3 ft. Hard & massive micaceous fine grained g
33 ft. Soft decomposed " " " " Gneiss.
White decomposed coarse grained granite
2 ft. Hard white coarse grained granite
33 ft. Hard granite and Syenite
10 ft. Disintegrated gneiss
Ore obscured by mass of rock.

FIG. 11.

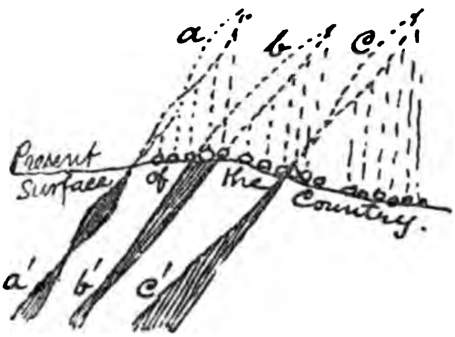


But nowhere do the number and irregularity of the ore-beds show more plainly than in the openings made on the Shaw range, and Shaw plantation, as will be seen by the plans and sections of the old revolutionary diggings, and the late shafts and trial trenches opened on that property, as given on page (25).

The distribution of pieces of ore over wide sections of the outcrop of the ore-belt, shows the same thing. Along certain narrow lines inside the belt, are to be seen multitudes of fragments lying on the ground, which have been left behind when the rest of the rock has been mouldered and washed away. And sometimes these fragments are a foot or more in diameter, although commonly smaller. Formerly, the ground was abundantly covered with them, but they were the first ore sought and used, and most of the large pieces and patches have disappeared during the war years of 1861, 2, 3 and 4.

Large pieces on the surface are the best evidence we can possess (in the case of unexplored ground) that the beds are of a good size, for they have come from those portions of the beds (a, b, c, &c., in the accompanying diagram, (fig.12), which have been destroyed in the general lowering of the surface of the country. There is no reason why the parts of the beds left under the present surface (a′, b′, c′, &c.), should not yield as large masses as the parts a, b, c, which have been mouldered away.

FIG. 12.



2. *The Size of the Ore Beds* varies as much as their number. They consist of strings of lens-shaped masses, continually enlarging and contracting in thickness, from a few inches to six and eight feet. The principal

beds may be safely estimated on an average of four feet, and in the best mining localities, the *average yield* of a long gangway may reach *five feet.*

The quantity of ore to be taken out of such a gangway is very great. Pure magnetic iron-ore weighs about 5 times as much as water, and 4 times as much as coal. Pure titaniferous magnetic iron-ore weighs scarcely less. A gangway in a four foot (average) bed, with an average breasting to the surface of sixty feet, will give mining access to about one hundred tons of ore to every running yard of gangway, or 176,000 tons to the mile.

This amount would exist above water-level, in one such bed, in one mile. It is needless to say that an equal amount would exist beneath water-level, for every sixty feet sunk on the bed. As a hundred and fifty yards of slope on a bed is very moderate and common working, a single mine, with gangways one mile long, and an average width of ore of four feet, has at its command more than *one and a quarter millions* of tons of ore.

It is not necessary to go into any further calculations of quantity on such a belt of ore-beds as that owned and leased by the Company. It is evident that centuries of heavy mining could not exhaust it, for each of the two or three principal beds may be entered and mined at fifty places.

3. *The Quality of the Ore* is a more important point, and on this head I can report favorably. It belongs to the family of the Primary Ores ; the same family to which the Champlain (or Adirondack) ores, the Marquette (Lake Superior) ores, and the ore of the Iron Mountain in Missouri belong. It is very similar to the New Jersey ores which are so extensively mined for the furnaces on the Lehigh river. It is a mixture of magnetic crystals, and specular plates of sesquioxide of iron, with quartz, feldspar and mica, in a thousand varying proportions. Sometimes the bed will be composed of heavy, tight, massive magnetite (or titaniferous magnetite), with very little quartz, &c. At other times the bed will be composed of a loose, half-decomposed mica slate, or gneiss rock, full of scattered crystals of magnetic iron.

The ore is, in fact, a decomposible gneiss rock, with a varying per centage of titaniferous magnetic and specular iron ore, sometimes forming half the mass, and sometimes constituting almost the whole of it.

The compact varieties will yield between 50 and 60 per cent. of pure iron, as in the case of the ore now being mined in the Sergeant Shaft, near the Forges. Mr. Frazer's analysis of this ore is as follows :

Magnetic oxide............73.56..........[Iron.........53.27 p. c.]
Titanic acid...............12.58...... .....[Titanium.....6.62 p. c.]
Residuum of quartz, &c..............12.86—with a trace of sulphur.

The specimen was obtained from the tunnel, a hundred feet beneath the surface, and shows an intimate mixture of crystalline titanic ore, magnesian mica, a little hornblende, a little labradorite, and a little specular iron.

This kind is difficult to smelt in the high-stack blast-furnace ; but makes the best iron in the world when smelted in the Catalan forge ; and is of great value for the lining of puddling furnaces. It serves the same purpose as the Lake Superior ore, which is brought in large quantities to Pittsburgh, and the surrounding district of Eastern Ohio and Western Pennsylvania, for lining puddling furnaces, and to mix with poorer ores in the blast-furnaces. Formerly, in the E. Ohio Mahoning district, the mixture was: one-fourth Lake Superior, one-half coal measure ore, and one-fourth mill cinders. Since the organization of the Lake Superior Iron Ore Trade, sufficient quantities come forward to enable the iron masters to mix one-half Lake Superior. The Sharon Furnace on the Beaver river runs *wholly* upon Block Coal and Lake Superior Ore. The titaniferous magnetic ores of the Ottawa region, in Canada, are also brought by a long and expensive route to Pittsburgh, to mix with Pennsylvania ores. These Canada ores are of the same geological age, and of the same mineral character, as the Tuscarora ores under consideration. There cannot be a question that these Tuscarora N. Carolina ores will command a high price at the iron works of Eastern Pennsylvania.

Trial of the ore has been made by Mr. Nathan Rowland, at his works in Kensington, Philadelphia. Five tons were forwarded for trial as lining to puddling furnaces. Mr. Rowland expressed his opinion that it stood up three times as long as the Champlain ore, which he uses for that purpose. The difference is due to the superior compactness of titaniferous magnetite over that of pure crystalline magnetite. I believe that your mining operations would be successful if they were entirely confined to this one branch of the business, so great is the demand for the best puddlers' lining ores.

I have said above, that the Tuscarora ores are essentially like those of Northern New Jersey. I referred to their age, situation, consistency, and general composition. But they have a peculiarity; they hold a notable per centage of *titanic acid.* The New Jersey ores seldom possess this property, and, in any case, only in a low degree. The Canada ores, and the ores of South Sweden, hold large quantities of titanic acid; even as much, sometimes, as between 30 and 40 per cent. A small—a very minute—quantity of titanium in pig-iron is believed to add greatly to its value, increasing its hardness and firmness, and its ability to stand wear. The Canadian ores were introduced to the Pittsburgh iron works for this end. But, seeing that almost all the titanic acid in any iron ore passes off in the slag, leaving a very small quantity to unite with the pig metal (sometimes in scattered crystals), it follows, that ores, which have an excessive quantity of titanic acid, cannot afford a high per centage of pig metal. It is much better to have an extra 20 per cent. of silex and alumina, potash or lime, in the ore, than an extra 20 per cent. of titanic acid; for these will make the ore easy to smelt, whereas the titanic acid makes it difficult to smelt; requiring a much higher heat in the stack to decompose than oxide of iron does. It is an advantage therefore, that, while many Canada ores hold 25 and 30 and 35 per cent. of titanic acid, your Company's ore has less than 15, leaving the per centage of metallic iron over 50. At the same time you have all the advantage which the presence of titanium affords: 1st, making the *ore* so firm that it is the best possible for lining puddling furnaces; 2d, making the *iron* tougher and harder, like the best Sweden iron; and 3d, imparting a certain quality (the cause of which is not yet understood) which adapts the *iron* especially for the manufacture of *steel.*

It would do no good for me to go into a metallurgical discussion here. It is sufficient, to inform you, that there is no question that titanium in iron ore favors the production of iron peculiarly suited to conversion into steel. The English steel trade has always largely depended on Swedish iron; and I believe that the titaniferous ores of the United States (and they are far from abundant,) will become annually more and more valuable, on account of the demand increasing for the best iron for steel-making purposes.

If these ores were smelted in large quantities in first-class anthracite furnaces, I do not think this particular value would appear; the small Swedish blast furnace must be used, or Catalan forges. This will be easy enough for the Company to do, seeing the country through which the ore-belt runs is heavily timbered, and charcoal can be obtained cheaply. I have no opinion to offer respecting the Dan river coal, distant twenty miles to the northwest, because neither the size, nor the number, nor the quality of the coal beds, has been determined. The coal is of the same age as that of the Deep river and the Richmond coal-basins, and would have to be most judiciously coked, if it could be used at all for iron-making. Charcoal must be the fuel for sometime; and there will be an abundance of charcoal.

The *lighter and looser varieties* of the Tuscarora ores have a lower per centage of iron in them, but will work more kindly in the blast-furnace. I had Mr. Frazer make me an analysis of a piece of outcrop ore from the Highfield plantation. It gave: Magnetic oxide, 44.53 [metallic iron, 32.25]. These varieties of the ore will do admirably well for smelting in blast-furnaces on the ground; but not so well for transportation to Richmond, Philadelphia, and other iron-making centres, as the purer, heavier and more refractory varieties described before. But they will make equally good iron, and iron as well adapted to the manufacture of steel.

The hard and soft varieties of ore occur often within a few hundred yards of each other; as, for example, on the Widow McCristen's plantation (14-15 miles), where the soft outcrops are seen on the hill opposite the house, and the hard ore lies in large chunks on the hill, south of the swamp. I append Dr. Genth's analysis of specimens from the two places, made at my request:

1. Massive ore from Mrs. McCuisten's Plantation. The analysis was so unexpected in its character, that Dr. Genth suspected some error, and repeated it, but with the same result. The small amount of titanium

shows the varying nature of the deposits. The percentage of iron is also low for this kind of ore :

Iron........................33.97 p. c.
Titanium.................... 1.60 [—2.63 p. c. titanic acid.]
Ratio of Titanium to Iron............................1 : 21.24.

3. Soft micacious ore from the same locality. The high per centage of both iron and titanium in this ore was equally unexpected, and was very gratifying ; for it will be seen from fig. 7, on page 17, that there is a total breadth of *ten feet* to this outcrop, in a space of twenty-seven. If any of the beds unite descending, the yield of ore will be great.

Iron........................43.47 p. c.
Titanium.................... 9.79 [=16.06 p. c. of titanic acid.]
Ratio of Titanium to Iron... ....1 : 4.44.

It is made known by the Canadian geologists that the constituents of some of these primary ores are combined in such a way as to approximate the rock to a diorite, or green-stone trap. Now, such a rock is seen on several of the Company's leases ; and especially on the Shaw, and other plantations two miles southeast of it. The people call its outcrop-pieces "nigger-heads." Some parts of the ore-bed itself become dioritic, and, therefore, less valuable.

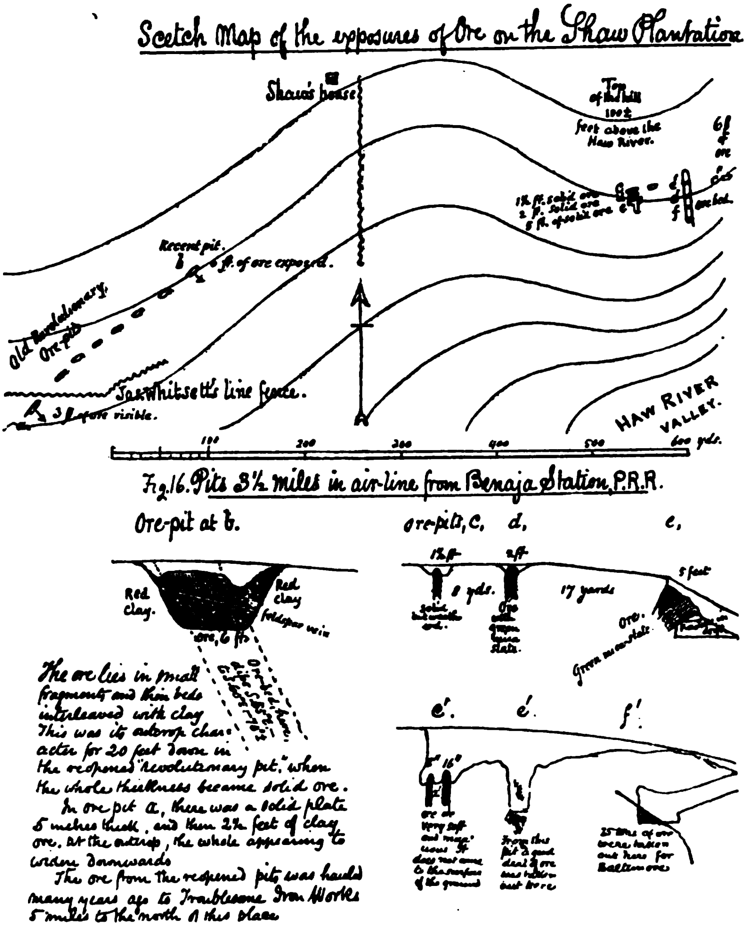
Great care must be taken to distinguish such massive, heavy, and *apparently* rich ores (which are in reality poor) from those which are really rich in iron, whether they be rich also in titanium or not. The most accomplished mineralogist can be deceived. Nothing but actual analytical examination can expose the fraud. No extensive mining operations should be undertaken, at any point along the belt, where the ores have not been fully analyzed, and the beds probed with the auger.

THE SHAW RANGE.

In fig. 15, page 25, I give a paced survey of the old and new openings on the Shaw plantation, running across its south line fence, on to the James Whittsell plantation ; and thence southwestward, probably, in a pretty straight line to the Highfield plantation. The absence of evidences of continuity on the surface is no good argument against it ; although it is possible that the deposit of iron in the bedded rock did not take place at certain points of the interval.

Northeastward, the Shaw ore-beds undoubtedly connect in a wavy-straight line with outcrops on the Alcorn and other plantations. Whether this belt actually joins the other beyond Troublesome creek, I have no means of knowing, but suppose it does.

FIGS. 13, 14, 15, 16.


Scetch Map of the exposures of Ore on the Shaw Plantation
Shaw's house
Top of the hill 100± feet above the Haw River.
6 ft of ore
d
e
f
ore bed.
1½ ft. solid ore
2 ft. solid ore
5 ft. of solid ore
Recent pit.
b
a
6 ft. of ore exposed.
Old Revolutionary Ore-pits
Jas Whitsett's line fence.
3 ft of ore visible.
HAW RIVER VALLEY.
100
200
300
400
500
600 yds.
Fig. 16. Pits 3½ miles in air-line from Benaja Station, P.R.R.
Ore-pit at b.
Red clay.
Red clay
feldspar vein
ore, 6 ft.
ore-pits, c, d, e,
1½ ft
2 ft
8 yds.
17 yards
5 feet
ore.
Green mica-slate
e'.
e'.
f'.
16"
Ore or very soft and micaceous. It does not come to the surface of the ground
From this pit a good deal of ore was taken out here
25 tons of ore were taken out here for Baltimore

The ore lies in small fragments and thin beds interleaved with clay This was its outcrop character for 20 feet down in the reopened "Revolutionary pit," when the whole thickness became solid ore.

In ore pit a, there was a solid plate 5 inches thick, and then 2½ feet of clay ore. At the outcrop, the whole appearing to widen downwards

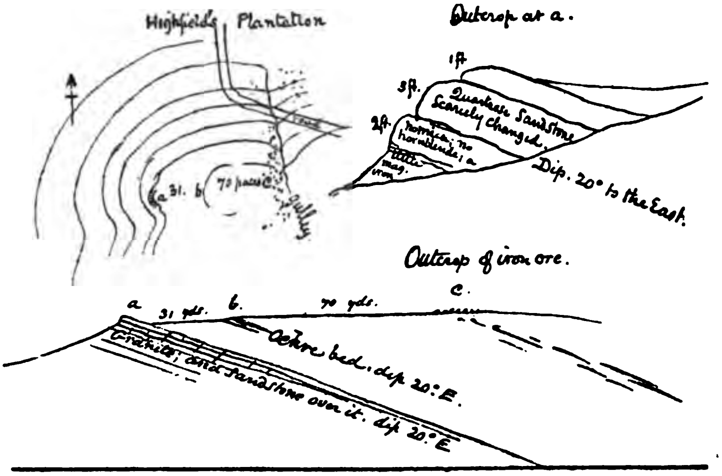
The ore from the reopened pits was hauled many years ago to Troublesome Iron Works 5 miles to the north of this place

At c''.... the ore-bed is full 6 feet across solid ore—a very green, chloritic, mica-slate, rock-ore. In this run of 800 yards, there are, *apparently, two hundred thousand* (200,000) *tons above water-level*, in the one six-foot bed.

The best development of the Company's ore-beds in the Northeastern portion of the property, as yet made, is on this Shaw Plantation, where three or four distinct and parallel beds have been opened, as seen in the preceding chart and diagrams. The direction of the bed changes somewhat, being N. 30° to 35° E., at the "Old Revolutionary Pits," and more nearly Easterly at the openings recently made by the Company. The whole course tested amounts to over half a mile. The beds at the outcrops vary in thickness from one to six feet. But owing to the thorough decomposition at the surface, a larger quantity of ore may reasonably be expected in some cases when the beds are followed down to where they become quite solid. The ore is good. The outcrop runs along the top of a hill, about one hundred feet above the bottom of the Haw River Valley, and can be tunnelled into at that depth. There are apparent variations in the dip, some of the outcrops seeming to be vertical, whereas the principal part of the mining has already shown a distinct dip towards the Southeast and South, which will diminish materially the necessary length of a mining (or draining) tunnel. In pit *f* of the chart, the dip seems to be scarcely 40°; and if this prove to be the regular dip, not only will the tunnel be comparatively short and inexpensive, but the quantity of ore to be taken out above it will be nearly doubled.

The Highfield outcrop shows that the ore beds lie in this Shaw range, at a much gentler angle than in the Tuscarora range; thus:—

FIG. 17.



One of the constituent elements of the whole formation is Ochre, in beds of various sizes. What the exact geological relationship of these ochre beds to the magnetic ore-beds is, I do not know. But the ochre outcrops seem to be always in the immediate vicinity of the ore-beds. The largest exhibition of ochre which I saw is on the J. Somers Plantation on Brushy Creek. Here an ochre bed twenty feet thick rises, nearly vertical, out of a gully in a hillside covered with small pieces of fine compact ore. The whole aspect of this place gives an impression of an abundance of ore beneath the surface; but no openings on the beds which have furnished these fragments have been made.

CONCLUSIONS.

1. The quality of ore on these properties, although various and suited to at least two branches of the iron manufacture, is of the very first rate: none better in the world.

2. The soft ores will smelt easily and make magnificent iron; absolutely the very best; perfectly malleable, tough and strong.

3. The hard ores will command a high price for puddler's linings; will be in demand for mixing with poorer ores of other regions, in the blast furnace, to increase the quantity and the quality of their pig metal; and will have an especial value for the Siemens and the Bessemer processes and the steel manufacture generally.

4. The quantity of ore is limitless.

5. Mining these ore beds will be profitable when the right localities are found and economy is observed. They can be mined by tunnels above water level, and by shafts to a great depth. It would be much better to sink deep at first; 200 feet shafts will be better than one hundred feet. The lower the beds are attached the less water will be to be lifted.

6. The beds are irregular both in dip, strike and thickness. But these, irregularities are local, short and sharp. They will not affect the value of the mine on a large scale, but they will cause small and momentary embarrassments without number. Therefore, mining operations must be well laid out in advance, and a steady policy be pursued in spite of whatever occurs in the mine. The number of tons to the running yard of gangway and of breast, will vary infinitely; but on the whole, for a year at a time, I see no good reason to doubt that a remunerative winning ought to be made.

7. The Shaw range is the best for mining, because its dips (S. E.) are gentler than those of the Tuscarora range (N. W). But the Shaw range ore seems to be more magnetic and less titaniferous, and better suited to the blast furnace. The Tuscarora range seems to furnish the larger quantity of titaniferous ore, best for the forge, the puddling furnace and to make steel.

8. In mining either range, on any plantation, I strongly advise the preliminary use of boring apparatus. A line of bore holes, at right angles to the outcrop should be made in every case, before sinking shafts or opening tunnels. It will save much money in the end, and will secure that knowledge which is essential to the best laying out of a large mine.

9. The dipping needle should be freely used along the whole ore belt, to determine the number and place of invisible ore beds. It will not always point out where larger masses or swollen portions of the ore beds lie deep beneath the surface. But it will be of very great use nevertheless. It will generally show where breaks in the run of the bed occur. It will also save much unnecessary surface digging.

10. A good macadamised road ought to be made from the mine to the rail road station. Or better yet, the wire and post system of transportation should be adopted. I think this system would work particularly

well in delivering the ore of the Shaw plantation, for example, across the valley of the Haw river, in the direction of Benaja station. In course of time a narrow guage railway may be made to follow the out crop of the ore-belt. The country is remarkably well adapted for cheap railways. Cuttings are very easy everywhere, and the whole country is virtually a smooth rolling plane.

11. Of course, it would be the best policy to bring the ores to nature on the spot. Small charcoal blast furnaces and groups of Catalan forges are possible, in a country so well provided with wood, and where any amount of labor can be got at the lowest price. It would be good policy, I think, to introduce the Siemens' furnace here.

12. Finally, the success of the Company's operations will depend upon their Superintendent's management. The geology is all right; the mineralogy is all right; the region is a good one ; population numerous ; food plenty ; labor abundant and cheap ; railroads at hand. Everything will depend upon management.

To illustrate by examples what can be done—The *Corwin* mine in New Jersey, is 100 feet deep, sunk to strike one of the group of Irondale magnetic ore-beds, a bed ranging from 3 to 10 feet in thickness, and dipping 45°. For twenty years past it has been producing an average of eight (8,000) tons per annum, from two shafts 75 feet apart. The Spring Mine and the Sullivan mine, are on two beds but a few feet distant from it, one from 3 to 5 feet thick, the other from 1 to 3 feet thick. The Hubbard mine has opened 200 yards of a bed of ore varying from 1 to 9 feet in thickness, to a depth of 200 feet, and has yielded 48,000 (forty-eight thousand) tons of ore in eight (8) years. It dips 45°. The North River mine 100 yards long and 200 feet deep, on a bed averaging 6 feet, has yielded 20,000 tone. The Orchard mine on a 3 to 9 feet bed, 400 feet long and 300 feet deep, has yielded 50,000 tons. The Huff mine about 200 yards long and 150 feet deep, on a 3 to 8 feet bed, has yielded about 50,000 tons. Munson's mine worked by the Boonton Iron Co., has two shafts 150 feet apart, and 120 feet deep, on a 4 feet bed, (only part of which is ore) yielded, when the last report was made, 16 to 18 tons a day. These examples will suffice.

13. Hauling ore to the Lehigh Iron Works in Eastern Pennsylvania, has been reduced to a system, and furnishes safe data for calculating expenses elsewhere. One of the largest of these works used last year 30,000 tons of brown hematite ore, and 20,000 tons of New Jersey magnetic.

Cost of hematite, $4.26 at the tunnel head, (1869-70).
Cost of magnetic $7.51 at the tunnel head, (1869-70).
Cost of magnetic $7.00 at the tunnel head, (1870-71).

This includes : royalty (.75), freight on railroad (1.30). and handling, but peculiar difficulties make *mining* cost $4.75 in the case of the particular magnetic ore used at their Works.

Their hematite ore mines average, in distance from the furnaces, six miles. Their ores are short-hauled, for from 50 to 70 cents, to a common "wharf" or central platform, whence the six mule teams carry it to the stacks. Economy demands that this be done when the roads are firm, and farmers' teams plenty. At Cold Spring, the ore-haul six miles, cost $1.20, now reduced to $1.10.

The North Carolina Central I. & M. Co., will pay—

For ore-leave, a royalty of	$0.50	$0.50
For mining, say	1.00	1.00
For hauling to railroad stations, average	.50	.50
For transportation to Richmond via Greensboro, 200 miles		4.00
For " " " from Benaja Station	3.46	
For " across the city at Richmond	.50	.50
For freight in return coal vessels to Philadelphia	1.50	1.50
For incidental expenses, say	1.00	1.00
Total cost of ore at Philadelphia	$8.46	$9.00

THE ACTION OF TITANIUM.

Although this is an obscure subject, something is known of it by actual experience.

J. H. Alexander, of Baltimore, in his report on the Manufacture of Iron, gives analyses of certain cinders, among which is one obtained in the smelting of a primary iron ore, containing, he says, 11 (eleven) per cent. titanic acid: the analysis is as follows:—

Silica	31.1	*Oxide of Titanium*	9.0
Magnesia	34.2	Protox. manganese	4.4
Lime	14.1	Protox. Iron	1.0
Alumina	8.9		

The ore, he says, was hard to smelt, and the pig-iron hard to work, but when properly made, is peculiarly adapted to the manufacture of steel.

The explanation is as follows:—Titanic acid will not combine readily with either the acid or the alkaline oxides. In every ton of ore (holding 10 per cent. of it) 320 lbs. of this neutral stuff exists, or (1½ tons of ore to 1 ton of iron) 330 lbs. of it in every ton of iron. If only 1-10 of this (or 33 lbs.) remains in the furnace, the gradual accumulation blocks it up. The only solvent of it are the double silicates of iron and lime, or iron and alumina and lime, or iron and potash and lime, &c. To make these double silicates, we must *waste* a good deal of iron. But the one object of the blast furnace is to *save* all the iron, and the best cinder is that which has no iron left in it, all the iron of the burden having gone down into the hearth as pure metal, (with enough carbon to make it fusible.) The Catalan forge, on the contrary, wastes iron, and its cinders are so rich in iron, that they are often worked over again ; hence, titanic acid is carried off, and does not obstruct the hearth. The forge fire is, therefore, the best to reduce titaniferous iron ores. But the blast furnace can smelt them also, if the heat be kept low, and some of the iron be allowed to go to waste in the cinders, to carry off the titanic acid and cinder mass. The object then, must be to make the utmost quantity of the most fusible cinder; therefore, a blast furnace running on titaniferous ores, should not be fluxed by pure limestone, pure clay, or pure sand, but with ferruginous clay, ferruginous slate, or ferruginous limestone. These fluxes will dissolve titanic acid *at a low heat.* To get gray pig iron, the cinder must be abundant ; to get white forge metal, but little flux is needed in comparison, the ore itself being wasted to form cinder. This *white iron with a large amount of carbon in it,* is just the metal from which German steel is manufactured. A high stack and a small hearth, like the Styrian furnaces, andferruginous fluxes, are the best for titaniferous ores.

Osborne says (page 475), that Mr. Henderson writes him that the Norwegian ores are successfully used at Norton, England, on a plan invented by John Player, although they contain (by one anlaysis)

Titanic acid		40.95
Perox, iron	22.63	51.59
Protox. iron	28.96	
Magnesia	4.72	7.81
Alumina	2.11	
Silica	.42	
Protox. mang	.56	
		100.35

being smelted in small furnaces with 1000°F temperature of blast, 2 tons of coal to 2½ tons of ore, 15 cwt. of limestone, 10 cwt. basalt rock.

"The iron becomes titanized, and is found to be exceedingly strong, and is used in Europe for armor plates, commanding *three times the price* of ordinary pig iron. The tensile strength of the resulting wrought iron, when puddled, is about 52½ tons to the square inch. There is very little carbon in the pig-metal produced, and *being almost steel,* in puddling it requires but half the time of ordinary pig metal."

Muchat's Steel is a *titanic iron,* with the peculiarity of being sufficiently hard after being heated red hot and forged, not to require tempering, but is comparatively brittle. Its color is not white, but has a tinge of straw color light brown.

Respectfully submitted,
J. P. LESLEY.

March 31, 1871.
Philadelphia, 1008 Clinton Street.

SUPPLEMENTARY NOTES, ANALYSIS, &C.

I.

Ochre Analysis, by A. Fesquet, 1869.

Sesqui. ox. Iron	19.43	[containing met. iron 13.60]
Silica	34.12	
Alumina	33.21	
Water, &c., &c	13.24	

In this ochre, which forms large beds on the outcrops of the more ferruginous feldspathic rocks, one has a superior flux for any heavy burden ore, especially for a close titaniferous ore. The ochre must become a fluid double silicate, without robbing the ore, and will carry off the titanic acid in excess.

II.

Ore Analysis, by F. A. Genth, in 1868.

Magnetic oxide	79.78	— iron 57.77
Titanic acid	12.08	
Oxide manganese	0.28	
Chrome oxide (trace of Vanadium)	0.32	
Silicic acid	0.75	
Alumina	4.62	
Magnesia	2.04	
Lime	0.13	

III.

Ore Analysis, by J. B. Britton, June 3, 1868.

Iron (protoxide) iron 21.20 + (peroxide) 39.40	— 60.60
Oxygen, with the iron in said 60.60	23.67
Mixed Sesquioxide, magnetic, &c.	84.27
{ Titanic Acid	4.95
{ Containing other insoluble matter	3.25
Alumina	4.81
Lime	0.24
Moisture	1.66

No phosphorus, and a doubtful trace of sulphur.

NOTE.—I have changed the order and wording of this analysis, to suit the others for comparison.—[J. P. L.]

IV.

Ore Analysis by C. Elton Buck, Wilmington, Del., Oct. 31, 1868.

Magnetic Oxide of iron	82.68	[—Iron 59.95]
Titanic Acid	8.72	
Ox. mang. 0.42. Sesq. ox. chrom. 0.40		0.82
Silica	1.89	
Alumina	3.93	
Lime	0.17	
Magnesia	1.36	

V.

Another, June, 1869.

Magnet ox. iron	81.30	[—Iron 58.52]
Titanic Acid	12.32	
Ox. Mang. and Ox. Chromium, and Sulphur		traces.
Silica	1.04	
Alumina	3.87	
Lime	0.64	
Magnesia	0.49	
No phosphorus		
Moisture and loss	0.34	

VI.

Ore Analgsis, by A. A. Fesquet, Nov. 12, 1868.

Metallic iron			60.41
Titanic acid		8.65	
Sesq. ox. Chrom	0.83	0.95	
Sesq. ox. Manganese	0.12		
Silica		1.50	
Alum.		2.90	
Magnes		2.02	
Lime		0.75	

No trace of Sulphur.

A mere trace of Phosphorus.

Analysis made by pulverizing several hand specimens, and mixing them first, to obtain an average result.

VII.

Ore Analysis, by A. A. Fesquet, July 6, 1869.

Specimen highly magnetic, and almost without moisture.

Metallic iron in combination with	57.30		79.14
Oxygen (calculated for peroxide)	21.84		
Titanic Acid			13.74
Silica		0.52	
Alumina		4.50	
Magnes		0.54	
Lime		0.72	
Sesq. Mang		0.69	

Trace of Chromium.

No sulphur ; no phosphorus.

VIII.

Bar-iron Analysis, by A. A. Fesquet, April 4, 1870.

"The samples of iron bars which you gave me to analyze have the following composition:

Metallic iron [includes what iron is combined with oxygen]	99.38
Insoluble calcined substances, [Silica, &c]	0.15
Carbon [and oxygen ?] [by difference]	0.47
Also, a trace of Titanic acid.	
	100.00

"I would judge from the nature of the samples, and former analysis, that the proportion 0.47 per cent. under head of Carbon, &c., is too considerable to be formed by Carbon alone, and comprises, very likely, carbon and oxygen. Therefore I would judge that part of the impurities is from oxide of iron, and the remainder from slag, which I have ascertained experimentally. In other words, the impurities are due to a highly basic slag, which cannot be expelled or squeezed out by the hammer and the rolls."

NOTE.—The above bars were rolled [from blooms of N. Carolina ore] by Jas. Rowland & Co., not cut and piled.

IX.

North Carolina Blooms made into Steel by the Martin's Process.

In January, 1871, Mr. A. A. Fesquét assisted at the conversion of ten tons of North Carolina blooms into steel, at Cooper & Hewitt's Works, Trenton, N. J.

The blooms were some of the first made at the Tuscarora Forge fires, rough and variable in size and quality, and weighing from 150 to 225 lbs.

Mr. Fesquét thus reports ;

The Siemens-Martin's Process consists in mixing steel scraps with pig iron. The Carbon of the pig iron reduces the iron oxidized by the flames; keeping watch, as it were, over it, and preventing the perpetually forming oxide of iron from forming a cinder with the silica of the furnace lining.

The charge being melted, it remains exposed to the flame until, and even after, all the carbon is burned off.

The exact moment is known by a series of samples being taken out, hammered and bent, hot.

If the samples be red short, Franklinite iron is added to restore enough carbon to remove the oxygen from the iron.

After one or two stirrings the metal is run into moulds.

The North Carolina blooms took the place of the steel scrap. The cast iron used was West Cumberland (English) pig, nearly free from sulphur and phosphorus, and with enough silicon and carbon to fit it for Bessemer use.

At the moment of complete decarburation a sample was taken. It was slightly red short. An analysis showed that the red-shortness was due to a minute proportion of oxide of iron and cinder, which had not been expelled because of the pasty condition of the decarburetted metal. Percentage of carbon less than 1-1000th part.

Franklinite was added; the metal became fluid, and was run into moulds.

The ingots were sound, and presented large crystals, of a clean gray color.

A sample from one was perfectly malleable, without a trace of hot or cold shortness, without a flaw, and homogeneous to all appearances. The large crystals were condensed under the hammer. The fracture was not jagged, and resembled that of cast steel of some degree of condensation and hardness.

In a word, *this* steel was malleable, homogeneous and tough, like the best steel produced in any other way.

Tried at the forge fire (by the same workman), it seemed to bear more heat for welding and hardening than will the ordinary steel (with a corresponding proportion of carbon).

Less carbon is necessary in the case of titanium steel than in the case of common steel, to arrive at the same hardness.

In the rolls, this steel manifested no difficulties, according to the testimony of Mr. Slade of the Trenton Works.

Waste: Three operations, 14,152 lbs. of metal in all; waste, 18.5 per cent., exceeding somewhat the waste when steel scraps are used; for the cinder in the blooms has to be purged off in the process, and secondly, the almost purely metallic titaniferous bloom iron is much harder to melt than scrap steel; is longer exposed therefore to the flame, and therefore wastes more. By adding pig metal this evil will find a remedy.

The peculiar qualities of this steel will no doubt be intensified when its own titaniferous pig metal is used with its titaniferous forge blooms.

A dose of Franklinite may yet be necessary. Mr. Fesquét thinks it acts by giving up carbon. He suggests, however, that possibly it acts through manganese; but as nearly all the manganese goes off in the slag, he thinks its peculiar use is to keep the cinder fluid, and taking the iron's place in the cinder.

NOTE ON A FINE UPTHROW FAULT AT EMBREEVILLE FURNACE IN EAST TENNESSEE.

BY J. P. LESLEY.

(*Read before the American Philosophical Society, May 3d,* 1872.

In a late visit to the works at Embreeville, on the Nolichuckee River, in Washington County, East Tennessee, I made a compass and barometer survey of the river valley and Bompas Cove, connecting the Furnace with its flux quarry and ore banks, tram road, washing ground, slack-water channel, etc., which will be found delineated on the accompanying map, drawn on a scale of 4,000 feet to the inch, with contour lines of 20 feet elevation to express the topography.*

The Furnace stands in the gap which the Nolichuckee makes through the last range of mountains on its way out from the North Carolina Highlands to the Great Limestone Valley of East Tennessee. A double rib of massive sandrock here forms a natural dam and mill-race, affording unlimited water-power, protected by projecting fragments of the sandrock outcrop from the most violent freshets. It is a scene of rare beauty, and a remarkably favorable location for any kind of industry requiring power. A broad terrace affords ample room for several furnaces and their dependent outworks, a village, mills of different kinds, and, in fact, for a Rolling Mill of the first class.

At present there stands here one Furnace, of small size, making 6¼ (six and a quarter) tons of metal per day at the time of my visit, a saw mill, an ochre mill, a village, store, church, and Superintendent's mansion.

A rope-ferry communicates with the State Road on the opposite shore. Jonesborough—the capital of the county, and oldest settlement in the State, on the East Tennessee, Virginia and Georgia Railroad, 32 miles from Bristol, 98 from Knoxville, 210 from Chattanooga, 236 from Lynchburg, 440 from Norfolk, and 391 from Richmond—is eight (8) miles distant from the furnace by this State Road. A railway could be made without difficulty over these eight miles, along smooth vales of limestone land, which head up towards Jonesborough. My barometer along the State Road gave me 200, 300 and 340 feet as the summit elevations above the river at the ferry. The intervals were from 50 to 100 feet lower. Railroad grade at Jonesborough was something under 200 feet above the ferry. A line might be located with maximum gradients of 50 feet to

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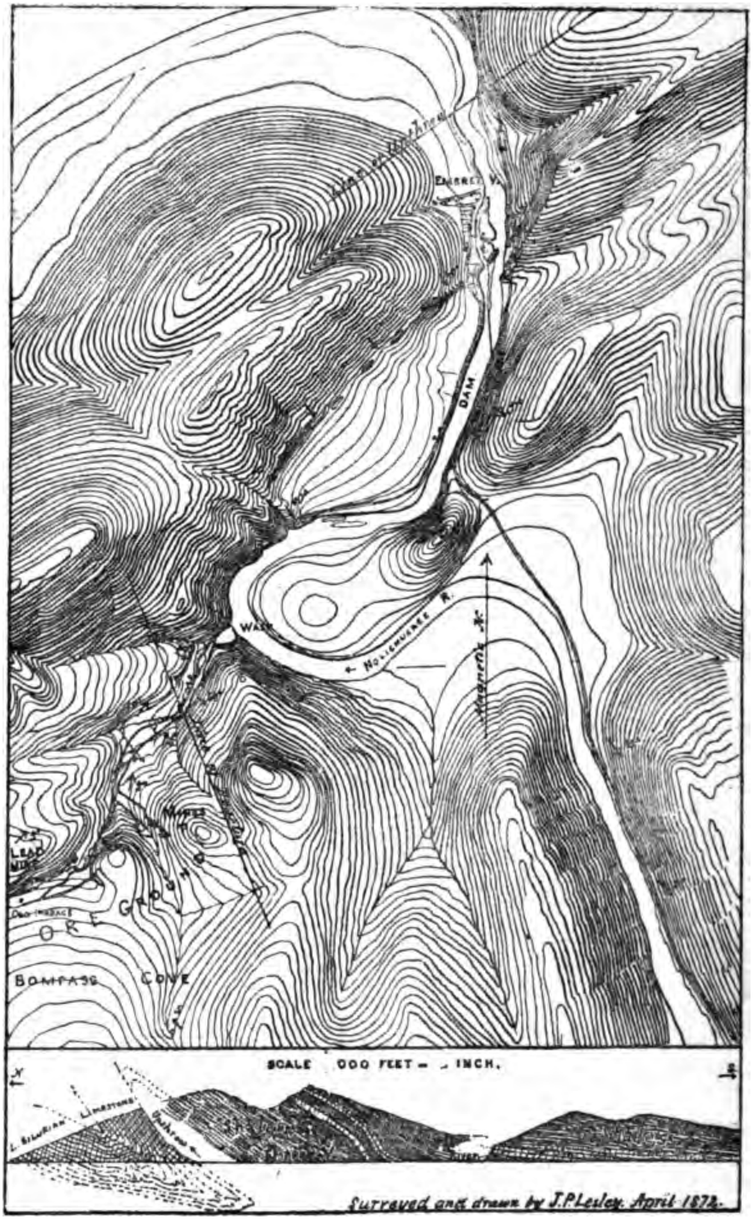
* The accompanying map was hastily sketched for reproduction by Mr. Bien's photo-lithographic process. It merely shows the character of the topography of a portion of the property. But it is accurate so far as regards the course of the river, the hills which enclose it, the sandrock outcrops, the north end of Bompas Cove, the grade contours of the railway and ravines, the elevation of the mines, &c. All the rest, including the heights and contours of the mountains, must be considered merely approximations to the truth. The contour lines represent elevations of 20 feet successively above tide-water, commencing at about 2,000 feet. The section below the map represents the geology along the river, above and below the Furnace. The scale was originally 1,000 feet to the inch. It was photographed down to 3,000 to make a plate. That plate was lost in the fire which rendered a second edition of this Number of the Proceedings necessary. An original copy from the first plate was then photographed down to 4,000 *feet to the inch,* to make the present plate.

2



Scale 4000 ft. to the inch.

the mile, and with little or no cutting and filling, except for the first half mile below the furnace in the gap. Ten or twelve thousand dollars a mile ought to be quite sufficient to build the road. The bridge at the Furnace would be 200 feet long, but would need no piers, nor abutments: these being provided by nature in the shape of colossal sandrock outcrops rising fifty feet above the river bed.

The metal made at the Furnace goes chiefly to the Tredegar Works at Richmond, 400 miles from the Furnace, costing $3.25 a ton to haul to Jonesborough, in the present state of the roads. In dry seasons, the limestone roads become smooth and hard.

Up the river to the south and east, locked in among hills of irregular trend, steep slopes, and bluffs of crumbling rock, from 600 to 1,000 feet high, lie two limestones coves: Bompas Cove, drained by Bompas Creek, flowing north into the river at the Furnace washing ground, two miles from the works; and Greasy Cove, drained by streams flowing southwestward to the river, and about six miles from the works.

Bompas Cove is an oval valley three or four miles long, by one and a-half wide at its widest part, surrounded by mountains about a thousand feet high, on the inner slopes of which rest terraces or hill-spurs .of decomposed limestone (Lower Silurian) holding masses of brown hematite iron ore of two varieties; the lower series (and outer, or closer up to the mountain wall) being silicious and cold-short, and the upper series being argillaceous and red-short. The cove is nearly encircled by the cold-short deposits, which have been opened in a number of places, and a good deal mined, towards the head of the cove, for an old furnace further south. The red-short hematites are extensively spread out more in the middle of the cove, where they are capped by lead-bearing members of the Limestone formation.

There are a few fertile farms in the cove; but an uninterrupted forest covers all the mountain country around it, most of which is included within the limits of the estate.

Greasy Cove is a large and nearly level limestone plain, more than twenty miles long by five miles wide, similarly surrounded by shale and sandstone hills nearly 1,000 feet high and backed by the State Line Range of the Unaka (Sub Silurian) Mountains more than twice as high. The Nolichuckee enters this cove from the mountain country to the south, and leaves it by a gorge, the south wall of which is a towering cliff of sandstone 500 or 600 feet in vertical height, called the Devil's Looking Glass. It flows thence three miles straight north-northwest towards the mouth of Bompas Cove, where it makes an ox-bow, and then flows north to the Furnace, as shown in the map.

This interval of three miles is made through forest-covered hills. Paddy's Creek and Broad Shoals Creek form narrow forest-covered valleys, entering the river valley from the southwest. Another stream of equal size forms a similar valley on the northeast. All this is good coaling ground for iron-works; and depots of charcoal can be established at different points on the two banks of the river, down which the fuel can be safely and cheaply boated. Two large charcoal furnaces at Embreeville could be erected in view of a constant supply of charcoal by the organization of an extensive system of coaling depots up the river. A forest surrounds the head of Greasy Cove and passes in an unbroken belt across all the hill country back of the river bottoms, over to the *Dry Creek Valley*, and Buffalo or Cherokee Mountain, north-northeast and east of the Furnace. This is on the east side of the river. On the west side, as I have said, many square miles of forest-covered hill country surrounds Bompas Cove.

This forest consists of white oak, spruce pine, poplar, hickory, etc., most of it in its original condition. Some tracts have been coaled off once, others twice. After fifteen or twenty years they are ready for coaling again. I saw a few trees two feet in diameter; but the forest trees are lighter than I am accustomed to see in Pennsylvania. They will probably yield, on an average, 40 or 50 cords to the acre, while some ravines will go up to 100.

The charcoal used at the Furnace is good and strong, but by the hauling over steep roads, and several handlings, the waste amounts to 25 or 30 per cent. Most of this could be saved under a more extensive and complete organization of this part of the business, and by the use of large baskets on trucks. The coal floors are near enough the Furnace to allow the carts to go to it twice a day; some, however, can be reached but once a day. The dependence of extensive works must be on a river navigation and coaling depots above, as has already been said.

One hundred and ten bushels of charcoal go to the ton of iron at this furnace, making, say, six tons. An enlarged stack could easily make ten or twelve. The Shelby Furnace in Alabama, sixty feet high, is making at the present moment, with charcoal, sixteen (16) tons, by information I have indirectly from the keeper, although it is reported she has made twenty. The report is incorrect; she has never exceeded sixteen. But this shows what *can* be done with charcoal and brown hematite ore. In smelting rich fusible lump ore, one ton of metal requires from *one-third* to *one and a-quarter* tons of hard charcoal, or from *one and a-half* to *three* tons of soft charcoal.

Coke, however, is the future dependence of Embreeville Works on an extensive scale. The Cumberland Mountain, west of Knoxville, (Coal Creek, Cove Creek, etc.,) has numerous workable beds of good bituminous coking coals. The Knoxville and Kentucky Railroad is already carrying these coals from the mines to the factories and ironworks of Knoxville and other towns along the East Tennessee Railroad, including Jonesborough. Contracts can be made for the delivery of any amount of Cumberland Mountain (Waldron Ridge) coal at Jonesborough, for $3.25 to $3.50 per ton. If the eight mile branch to Embreeville were built, costing with bridge and rolling stock, say $150,000, the coal could be landed at the Furnace at a cost of something under $4, and there coked;

or, which would be better, coking establishments could be organized in the Cumberland Mountains, along Cove Creek, and the coke be deposited at Embreeville for about $4.50, owing to the fact that—1. One-half the weight of the car-load would be saved by carrying it in the form of coke; 2. The waste in dust would be saved; and, 3. The slake waste at the mines would be coked with the lump.

Now, 6¼ cents a bushel is paid at the Furnace for charcoal, or, 6¼×110 — $6.87½, to make a ton of metal.

Coke furnaces require from 1.1 to 2.3 tons of coke to make 1 ton of iron, according to their size, shape, and especially the quality of ores employed. For brown hematites it would not be safe to assume less than 1½, and it might go up to 1¾ tons of coke to one of metal. If coke could be got at Embreeville for $4.50, the coke for 1 ton of iron would still cost $6.75, as against $6.87½ for charcoal.

But while a charcoal furnace is producing 45 tons of metal a week, a coke furnace with hot blast is producing from 150 to 200 tons a week.

It would be unwise to erect more than two first-class charcoal furnaces at a point like Embreeville, in view of the extensive and complicated system of coaling and boating required. These would make 10 tons a day each, or 140 tons of metal per week. Whereas four coke furnaces might be put in blast safely, making together (with one always out for repair, etc.), say 3×150—450 tons of metal per week; or even 600 or more.

On the other hand, no profit could be made on coke bought at the mines; and no profit on coal, but only on the coking of the coal at the Furnace, by supplying store goods for wages; whereas, the 6¼ cents per bushel paid for the charcoal is paid in stores, and a large saving accomplished.

The same is true of other labor, at the Furnace and at the mines; but this would not be changed by the substitution of coke for charcoal.

Another consideration, and one of importance, is the change in the quality of metal produced. So long as the lowest beds of the Cumberland Mountain system are mined, the coal will be second rate, and even if the best precautions are taken, the coke will not be so good a fuel as charcoal. Quality of metal would have to be sacrificed to some extent for the sake of quantity. The metal made at Embreeville could hardly be better than it is; exceedingly strong in the pig and much esteemed for car-wheel use. The price of such iron must always be high, whatever be the state of the seaboard and foreign markets, because of the limited amount of it made, and always to be made. Much, if not most, of the Tennessee iron must always be cold-short on account of the wide distribution of cold-short ores through the country.

The Brown Hematite, or limonite, deposits of Bompas Cove exactly resemble those of Morrison's Cove, Nittany Valley, Kishicoquilis, and other Lower Silurian limestone valleys of Pennsylvania and Virginia; and those of the long line of the north flank of the South Mountain (Blue Ridge, Smoky Mountain range) from the Hudson River to Alabama. They are in fact situated geologically just like the Allentown, Carlisle, and Chambersburg deposits.

These ores are irregular masses of ochreous clays and loose sands, full of shot and balls and pipes of the hydrated sesquioxide of iron; with coatings of the black oxide of manganese, and traces of the original sulphide of iron, sulphide of lead, and sulphide of zinc, held by the limestone strata before these were dissolved and made cavernous by the drainage waters which have packed the clay sand ore into all the holes and crevices, caves and water-courses thus made.

The general dip of the limestone beds in Bompas is about 10° north-northeast, against a fault which crosses the mouth of the cove and seems to run in a line about N. 15° W., S. 15° E. All the rocks to the east of this line—the rocks in which the river flows—are of an older age, and dip 60° S. 40° E., in very straight bold outcrops, as represented on the map and in the section accompanying it.

This gentle dip of the limestone has exposed several square miles of the ferruginous lower limestone to decomposition; and the quantity of ore is correspondingly great.

The limestone has been cross-cleft; its cleavage planes dipping 45°, more or less. The dissolution has followed these cleavage planes. The ore-clays are packed in descending cavities sloping at that angle. The massive ore seems to dip 45° therefore, instead of 10°. But as several hundred feet of the nearly horizontal limestone beds has converted itself more or less into ore, the quantity of ore is immense.

The series of ore pits from which the furnace has supplied itself, ranges up the side of a steep hill, beginning at an elevation of about 200 feet above the river (one mile from it), and ending at an elevation of 350 feet. But the ore continues up the hill a hundred feet higher; and descends also below the lowest pit. No system has been observed in mining the ore. Everything has been done hap-hazard and in the most expensive way.

The stripping varies from a foot or two to twenty and thirty feet. The solid ore-ground, consisting of from one-half to four-fifths fine ore, the rest balls, with occasional masses of clay, and occasional masses of solid hard limestone rock (left in its original condition, but with all the edges dissolved round), has been dug into to a depth of ten, fifteen, twenty feet, and more in places, without reaching bottom.

I judged that I saw along the line of pits over the end of the tramway, about one million of tons of ore.

The ore can be followed over the top of the little hill and down its northern side.

Abundant evidence of ore covers the long slope of the hill towards the south for a quarter of a mile.

The same limestone beds take into the isolated hill to the west; and on both sides of this hill near its top are old diggings of the ore, from which the original furnace was supplied for a good many years, and abandoned when that furnace was abandoned, and the new Furnace was erected at Embreeville. The old furnace was situated on Bompas Creek, about half a mile southwest of the present ore mines, and just opposite the lead mine shown upon the map, but inconveniently far from the river.

There must be millions of tons of iron ore in the more central part of the cove, in the low hills composed of the almost horizontal ore-bearing limestone strata, which everywhere show the dissolving action of the ore-collecting waters, and are covered in many places with ore-ground.

The books of the Furnace show that after the ore has been washed and the large lumps roasted to make them more easily broken to pieces, the lowest percentage of ore to pig metal is 49, and the highest 59. The *practical average* of pig iron obtained from the thus prepared ore is fifty-five per cent.*

The weight of the washed ore when dry is one and a half (1½) tons to the cubic yard. The weight of the lump ore is about 1¼ tons to the cubic yard. One car-load of 44,919 cubic inches measurement, *thoroughly dried wash ore*, weighed 3,042 lbs. One cubic yard — 46,656 inches. The lump ore of one car weighed 2,570 lbs.

Very little flux is required by the Furnace, and this is obtained from bold outcrops of blue limestone on the State Road two-thirds of a mile north of the ferry. There is so much lime in the wash ore and in the clay of the ball ore, and so heavy a charge of manganese in the ore deposit that the fluxing of the stock scarcely adds to the expense of its smelting. The cinder is excellent and the waste of iron is evidently small.

Around the inside lining of the tunnel head for about four feet down from the lip of the filling-hole, there forms a coating of concentric layers of a very solid and heavy substance, consisting chiefly of metallic zinc, in alloy with metallic lead and a small quantity of metallic iron.†

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* Analysis of Brown Hematite ore from Bompas Cove, E. T., made by Prof. Fisher, of U. S. Naval Academy, Annapolis, Md.:

Water and organic matter,	13.15
Phosphoric acid,	.09
Silica,	3.05
Alumina,	1.28
Sesquioxide of manganese,	.27
Sulphur,	.203
Peroxide of iron,	82.27
	100.313

82.27 peroxide of iron equals 57.6 per cent. pure iron.

† Analyses, by Persifor Frazer, Jr., Assistant Professor of Chemistry in the University of Pennsylvania, of—

I. *Furnace product* from Embreeville Works, N. C., taken from within four feet of the tunnel head: A hard, brittle, gray solid, with occasional streaks of green, but in powder is grass-green. Specific gravity, 5.6.

Under the magnifying glass it shows minute metallic scales which impart a metallic lustre to the streak when the product is scratched, and yet bear such a small proportion to the whole mass that they are almost indistinguishable with the naked eye.

Silica,	0.28
Iron (calculated as sesquioxide),	4.12
Zinc (oxide),	84.26
Lead (metallic),	6.18
Carbon (as finely divided coal dust determined by loss),	5.16

The upper and more solid blue and white limestones of Bompas Cove, exposed along the banks of the creek, opposite the old furnace site, contain a good deal of disseminated galena. This is decomposed into carbonate of lead, filling crevices which have been followed down by shafting operations during the late war. The two ores of lead were taken in cars, on a tram road a few hundred yards long, down the creek to a lead mill erected by General Jackson, and there smelted for the use of the Confederate army. The works are now abandoned, and the shafts filled with trash or water.

Brown hematite iron ore deposits have also resulted from the decomposition of the limestone beds over the lead-bearing strata.

Greasy Cove is a district of limestone similar to, but much more extensive than Bompas Cove, and carries the same brown hematite iron ore deposits of probably equal size. The hills overlooking the flat land of this cove on the northwest and within half a mile of the river, are red with ore.

These details are not only interesting in themselves, but necessary for familiarizing the observer with the scene of a geological action, common enough in our Appalachian region, but rarely exhibiting itself in so bold and telling a way as at Embreeville.

A fault—an upthrow and overshove—a collapsed synclinal at the edge of the thrown-down mass—all this is presented to the eye of the structural geologist, as he stands on the steps of the little Church of Embreeville and looks across the river eastward. Hundreds of feet of limestone outcrop, in part natural cliffs, in part quarry work, demonstrate the problem of Cambrian overlying Silurian—the Quebec Group overriding Trenton Limestone—by drawing it in a grandly visible diagram, a mile long, by 800 feet high.

The solid plates of limestone are bent round in the synclinal without fracture (other than at the great cleavage planes) as though they had been as plastic as wax. A slight anticlinal roll immediately precedes the sudden upturn to a vertical followed by a declining angle in the reversed sense. The exact place of the fault is obscured by a general crush and sheet-covering of the finely broken shale and very thin bedded shaly sandstone layers which make the rest of the mountain mass.

Up through these sandy shales, dividing them into an upper and lower system, rise the bold outcrops of two conglomerate beds, each about 20 feet thick. One of them, forming the crest of the mountain east of the river, descends in a dyke to the water, sinks under the valley, and reappears to face the slopes at the bend at the mouth of Bompas Creek. The

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II. *Lining stone* of Embreeville Furnace, N. C. A yellow sandrock used for the lining of the Embreeville Furnace, and remarkably lasting, was proved to contain:

Silica, - - - - - - - - -	76.99
Alumina and Iron (latter under 2 p. c. $Fe^{2}O^{3}$), - - - -	16.12
Magnesia, - - - - - - - - -	2.63
Lime, - - - - - - - - -	1.44
Undermined, - - - - - - - - -	2.83

Considerably more than 50 per cent. of the Silica given above seems to exist as free Silica, or sand.

other forms a dyke along the foot of the mountain from the Furnace southwest to Bompass Cove. These two coarse sandrocks or finely brecciated conglomerates are shown in the diagram at the foot of the map on page 445, above.

It will be noticed that another set of sandrocks, not at all conglomerate, but semi-crystalline in texture, and (with alternations of softer kinds, and shale bands) at least 100 feet thick, come in above and (being nearly horizontal) cause that hog-back topography seen in the horseshoe bend of the river. It will be noticed also that above these last sandrocks, lies a third or uppermost system of sandy shales. These constitute (with some still higher intercalated massive sandrocks) the bulk of the inwalling river hills (600–800 feet high) all the way up (about 3 miles) to the entrance into Grassy Cove; that is, to the next parallel fault throwing down the Silurians.

It will be evident to those familiar with this characteristic structure of East Tennessee and Southwest Virginia, that the Nolichuckee River exposes a nearly transverse cross-section of a long prism of earth-crust composed of sandy shales, sandrocks and conglomerates, at least 600 feet thick, *elevated* between enclosing *sunken* countries of Lower Silurian Limestone.

There is no sign of squeeze and distortion along the southern (Greasy Cove) fissure, for the uplifted upper shales abut there horizontally against the down-thrown limestone prism to the south of it. Whereas in the Embreeville (or northern) fault, the lower part of the shale prism has been lifted and thrust violently against the limestone prism to the north, so as not only to override it, but to curl up the ends of its beds into a collapsed synclinal. The force has therefore come from the south, and acts northward, or north-northwestward. This is not only in accordance with the law of anticlinal structure, made out in Pennsylvania by the survey under Prof. H. D. Rogers, 35 years ago, but with nine-tenths of the fault exhibitions in Virginia and Tennessee.*

What the rock system is, a prism of which has thus been upheaved between the two Lower Silurian districts of Jonesborough to the North, and Greasy Cove to the South, is still a subject for discussion. Mr. Safford, State Geologist of Tennessee, gives it the name of Chilhowee, without identifying it closely with any of the great Formations of the Northern States. It probably underlies immediately the Lower Silurian Limestones.

One thing is remarkable: its apparent total lack of iron ore and limestone. There is no appearance of metamorphism throughout the 6,000 feet of rock trenched by the Nolichuckee.

The cross-fault of Bompas Cove, on the west side of which the L. Silurian Limestones are dropped to water level in an almost undisturbed

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* I have recently exhibited to the Society cross-sections of this structure, in Tasewell, Wise, and Scott Counties, Virginia, which, when published in the next Number of these Proceedings, will make this law sufficiently comprehensible.

(horizontal) condition, is, perhaps, the most interesting feature of the dynamic scene I am trying to portray; but it must remain for some geologist to study who has more time at his command than I had, in my hurried visit to Embreeville.

These cross-faults are incidentally mentioned by Mr. Safford, on page 200 of his Report of the Geology of Tennessee for 1869, when he says:

"484. At the ends of these mountains, the sandstones which form them are suddenly and curiously cut off, and wholly disappear. The mountains and their rocks, of course, lie generally immediately on the southeast side of a fault. The sandstones, broken in wide blades, appear to have been thrust up endwise to the northwest, through the overlying formations. The displacement is, in some cases, very great. In the case of Chilhowee Mountain (see section page 190), the sandstones, or, rather, Ocoee conglomerates, have been brought up and abutted against *Carboniferous Limestone.*"

The expressions used in the above description are calculated to obscure the picture to the eye of the reader. The sandstones are prominent objects in the landscape; but they are integral and very subordinate items in the mass of the upthrown (and often but slightly tilled) prism of earth-crust. To a depth unknown to the observer, the earth-crust in all this region of Virginia and Tennessee has been cracked along straight, parallel lines of great length (some of them a hundred miles), but of no great width, seldom over five miles. In Mr. Safford's Section (page 190), across Eastern Tennessee, from the carboniferous table-land, southeastward to the Metamorphic Azoic Mountains of the North Carolina line, 52 miles, there are *eight* of these faults noted, making the average width of each prism (supposing no fault has been omitted) 6½ miles.

The upthrow or override of the side face of each prism against the prism to the northwest of it, varies from fifteen thousand (15,000) feet (as in the Chilhowee Mountain Fault above cited, and in the Montgomery and Wythe County Faults of Virginia) down to five thousand, as in the case of the Embreeville Fault, and others of a like kind, in the same range, where the bottom measures of the Chilhowee, or top measures of the Ocoee, Formations abut against the Trenton Limestones.

The tilt of a prism, five miles wide to an elevation of only one mile on its northwest border, gives an average dip of 1 in 5, or 10°. But the tilt has been produced by a thrust from the southeast, violent enough not only to produce the tilt, and thrust the prism forward and upward, but to rub up the broken edges of the layers of the down-tilted next prism, and to rub down the broken edges of its own layers; and, moreover, to bend the whole body of the prism along its northwestern limit. Consequently we have *there* dips of 45°, whereas the dips everywhere else (with trifling exceptions) are scarcely more than 5°.

It may be said, therefore, if astonishment be expressed at the vastness of these upthrows, considering the weight of the prism, that, in fact, there has not been so much upward movement after all.

On the other hand, in the sections I have made across sets of these faults, in other parts of the region, and where the uptilt is of lower Silurian Limestone against Coal Measures, repeated again and again, the proportion of horizontal to vertical is as 5 miles to 3 miles, and a dip of 30° pervades the entire body of the prism, and of *each* prism, from side to side.

This is a very astonishing state of things. And it characterizes a region of country fifty miles wide by five hundred miles long, roughly stated.

What supports these long untilted prisms of earth-crust?

We cannot imagine an underground Pre-silurian topography arranged with such regularity, as to allow the settlement of the sections of Paleozoic series, in straight lines, hundreds of miles long, and always on one side, the southeastern.

It seems to me evidently necessary to assume a (in some sense) plastic underground, on which these wonderfully regular prismatic rods of Paleozoic rock have been able to roll one-third over and adjust themselves.

The alternative must be, that the vacancies (of triangular section) have been filled with the debris of the lower crushed edges and bottoms of the prisms,—a most unsatisfactory suggestion—especially unsatisfactory, because the regular over-roll of all the prisms in one direction proves that the laterally acting energy (whatever may have been its origin) was acting on a great plate of Paleozoic rockmass, at least (counting in the coal measures) *four miles thick;* solid, although flexible, itself; but free, when broken, to slide on its foundations, as the broken up flakes of ice slides over the water which supports them.

That there was no absolutely fluid (lava?) underground beneath them is evident from the total absence of volcanic rocks at the present eroded surface, along these faults, even when the uppermost *Subsilurian* rocks appear in one wall. (The numerous warm springs connected with the Virginia faults are explicable on chemical principles, no doubt.) But beneath the uppermost Subsilurians are vast formations, all more or less metamorphosed, and many converted into granites and other crystalline forms. Here we have the plastic mass we need, over the surface of which (of course, an eroded surface, but, probably, eroded to a plane containing no Alpine or even Subalpine inequalities) the Paleozoic deposits, consolidated by time into a consistent, but never yet dried, sheet, seven miles thick in Pennsylvania, five miles thick in Virginia, three miles thick in Tennessee, moved with a certain freedom, under a lateral pressure, from the southeast, at the close of the Coal Era.

I have formerly taken occasion to ascribe the difference of effect exhibited by this pressure in Pennsylvania and in Tennessee to the difference in the thickness of the Paleozoic mass. In Pennsylvania it was folded ; in Tennessee dislocated. But the difficulty which pressed on Mr. Rogers to explain the sustentation of the vaults of our Northern anticlinals, is encountered equally by the Southern geologist who will explain the stable equilibrium of his tilted prisms.

To return from this digression to the cross fissures, which cut off the ends of the Chilhowee and other mountains (and an example of them is given in my map of Bompas Cove), it must be understood that they do not obey one law, as do the principal and parallel dislocations of the country. They sometimes run square across from one of these to or towards another; seldom cutting a prism entirely off; usually cracking its north western edge for a certain distance into its body. It is a subordinate and secondary system of faults. But by means of it most of the Appalachian ridges or mountains, of Middle Silurian and Upper Divonian age, are swallowed up and ended at the surface; just as are the mountains of Chilhowee sandstones, in such cases as that described by Mr. Safford above.

The section accompanying my map will, perhaps, be compared by some reader of this paper with Mr. Safford's section on page 202, and they will be seen to be very different. It is only needful to explain that my section was made with instruments on the ground under favorable circumstances, and carefully drawn to the same horizontal and vertical scale; whereas the section on page 202 is like Mr. Safford's other sections, drawn to a vertical scale at least twenty times greater than the horizontal, and, as he says, "it is not intended to be accurate in detail."

In fact nothing can be more erroneous than the impression on the mind of a young geologist produced by the section. It not only distorts the facts, but bars the way to a right understanding of the structure not only of this locality at Embreeville Gap, but of similar localities along the Unaka Mountain range.* There are no such synclinals as are there represented. There is nothing which in the remotest sense resembles the anticlinal there drawn under the letter D. That interval is essentially and wholly monoclinal.

Every student of American geology must acknowledge his great indebtedness to the assiduous and judicious State Geologist of Tennessee, who has done so much to elucidate one of the most interesting regions of the United States. Among the many valuable columns of thicknesses which he has published, the following (in § 489) justifies the statement I have made relative to the amount of rock visible along the river above Embreeville. It represents the Chilhowee Group, in Doe River Gap, Carter County.

Top of Section:—Quartzose sandstone	55 feet.
Sandstones and Shales	70
Quartzose Sandstone	10
Sandstone and Sandy Shales	250

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* With the highest respect for the distinguished services rendered our science by the State Geologist of Tennessee, I cannot refrain from expressing regret that the weight of his standing in the science should be thrown into the scales on the side of the slovenly and mischievous fashion of distorted drawing in vogue among geologists until recent years. A section is worse than worthless which is not well and truly drawn. It is sure to manufacture and perpetuate false views.

Quartzose Sandstones	35 feet.
Sandstones and Sandy Shales	370
Quartzose Sandstone	40
Thick and thin bedded Sandstone, generally dark colored, occasionally Sandy Shales, and but little fine conglomerate	1,720
Quartzose Sandstone	40
Thin Sandstones and Sandy Shales	320
Sandstones and fine conglomerate with two Quartzose bands	275
Heavy bedded Quartzose Sandstone	38
Sandstone not well seen	180
Heavy Gray Quartzose Sandstone, with unimportant layers of fine conglomerate	60
Sandstones with conglomerate, dark and even bedded	44
Heavy Gray Quartzose rock, mostly sandstones with fine conglomerate	60
Some of the Sandstone hard and Quartzose	472

The lower part of my Embreeville Section consists of between one and two thousand feet of sandy shales, with two very massive plates of conglomeratic sandstone, about twenty feet thick. Two or three thousand feet more, higher up, consist of massive sandstones and heavy beds of shale alternating. Just overlying the upper conglomeratic sandstone plate are variegated clay slates.

It is impossible not to see the significance of the immense development of sandrocks and pebble rocks, in the Ocoee and Chilhowee systems, underlying the Lower Silurian Dolomites, and hugging the flank of the backbone of the Continent, for a thousand miles through Virginia, North Carolina, Tennessee and Georgia, as in New Jersey and New York. It is a shore deposit on an immense scale, in a shallow sea, with a steeply inclined margin, and an Alpine range inland. No glaciers ; for the conglomerates consist of rolled shingle. stones ; but torrents, innumerable and vehement. No large rivers ; for no delta deposits of any size are apparent. A rapid degradation of the mountains was followed or stopped by a partial submergence, which deepened the sea, made the sand deposits finer, and permitted the deposit of the Lower Silurian limestones.

The reason therefore why the massive Quebec Group (Potsdam, Chilhowee and Ocoee) formation does not come up to daylight in the faults which break the middle and northwestern parts of the floor of the region under discussion, is because it thins away rapidly seaward, that is, westward, towards the Coal Area. And in this it only sets an example afterwards followed by the sandstone and conglomerate members of the great Palæozoic system : Nos. IV, IX, X, and XII the Millstone Grit.

SCOTT, WISE, TAZEWELL COUNTIES,

VIRGINIA.

LESLEY.

THE GEOLOGICAL STRUCTURE OF TAZEWELL, RUSSELL AND WISE COUNTIES, IN VIRGINIA.

BY. J. P. LESLEY.

(Read before the American Philosophical Society, April 21st, 1871.)

I was called upon recently to examine a part of the Alleghany Mountain Range, between the New River (Kanawha) in Middle Virginia and the north line of the State of Tennessee, for the purpose of determining the nearest possible approach to a workable coal region of a contemplated Railway from Harper's Ferry on the Potomac to Knoxville in Tennessee.

The geological structure of this part of the United States is so peculiar and so nearly unknown to geologists, or at least unnoticed in any published memoirs, that I have taken some pains to portray it, believing that it will be an acceptable contribution to the literature of the science and to the proceedings of this Society. The present paper is, however, a virtual continuation of my description of the South Virginia Coal region of Montgomery and Wythe Counties, read before this Society in 1862, and published in Vol. IX of its Proceedings, pages 30 to 38.

Professor William B. Rogers, State Geologist of Virginia, is well acquainted, no doubt, with the essential facts about to be described, and probably has materials for a more extensive description of the central belt of the Appalachians among the unpublished archives of the State Geological Survey of Virginia; but I doubt that any sections have been constructed which express more clearly the state of things in a geological sense, than those which I have this opportunity of making known.

Professor James M. Safford, State Geologist of Tennessee, has studied the Southern continuation of the belt, and describes it in his Geology of Tennessee, Nashville, 1869. But the sections given in that valuable work, which has cost its author so much time, skill and labor to prepare, and for which American Geologists are most grateful, are only adapted for general description, not being drawn to a natural scale, and are not of use for the critical study of the dynamic problem here offered to the consideration of structural geologists.

The map which accompanies this paper was made to show the railway avenues through the region above named, by bringing out clearly its main *topographical* features. I have colored it to show to the eye its main *geological* features, especially those due to the lines of Downthrow, which are also the lines of limit for the Coal Measures. I have confined the coloring within narrow limits so as not to obscure the prime facts. No distinction is made therefore between the Calciferous, Trenton, Birdseye, Black River and Hudson River formations, all of them being colored *blue*, representing the *limestone valley formations*, Lower Silurian, Nos. II and III of the Pennsylvania nomenclature.

The Oneida Conglomerate, Shawngunk Grit, and Medina Sandstone, Middle Silurian, No. IV, are left uncolored, to make their mountain character more conspicuous. The Upper Silurian, Clinton, No. V, carrying the Dyestone, Fossil Iron Ore, is colored red, to catch the eye, because of its practical importance for railway purposes, and because it is the red formation of the North, *par excellence*, although it is not so marked in nature along its southern outcrops. If the native coloring of the soil were to govern the tinting of the map the Hudson River slates (No. III) would require this pigment.

The Devonians are represented by a Vandyke brown wash (Nos. VIII, IX, X), and the Coal Measures by a wash of Payne's gray. No color is allowed for No. XI., which shows so prominently on the geological map of Pennsylvania in red, because its outcrop is feeble here and *not* especially red.

The main features of the topography are quite correct (except near its eastern end, of which I can say nothing); and it distinctly shows how the mountains are made, by the downthrows, to run in pairs, with a "poor valley" between each pair, consisting of Devonian Sandstones and Upper Silurian shales containing the Clinton, Dyestone, or Fossil Iron Ore; and how the pairs are separated by wider Lower Silurian limestone or "rich" valleys, containing the villages and farms of blue grass and scattered and probably extensive deposits of Brown Hematite Iron Ore, which I have *not* colored.

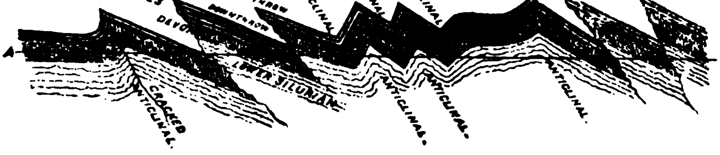
The black lines 1, 2, 3, 4, &c., show where the vertical geological sections in this report are to be looked for on the map.

There is no map of this country worthy of the name. I have copied the State map and then changed its details according to my observations. The geology is perfectly simple, when one has the key to it. The key to it is given by the pairing off of the mountains along the Downthrows.

I begin then with this curious and all important phenomenon. Fig. 1, shows it in a *purely ideal* way; but reference must be made to Sections 1, 2, 3, 4, &c., for its *actual* representation in different places.

Fig 1.

IDEAL CROSS SECTION, SHOWING THE CRACKS OR DOWNTHROWS



What the power was, which cracked the anticlinal and synclinal curves, and shoved the 10,000 feet of Carboniferous, Devonian, and Silurian Formations over each other, like cakes of ice in a river freshet, it would be premature here to discuss.

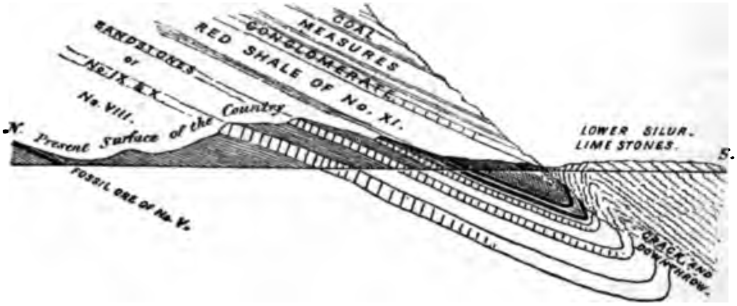
The consequence has been, that along the straight lines of these cracks —lines running for fifty or a hundred miles,—the coals at the top of the system abut against the limestones near its bottom.

Another consequence has been that no coal is to be found but on the north side of each crack. The whole mass of rocks above the line A—B has been removed (it is needless to describe the process, which is still going on and can be studied by any observer), so that the vast coal field which once covered this country is no longer in existence ; and the only remnants of it left are long stripes, a few hundred *yards* wide, running along the north lip of each crack.

A third, and equally important consequence, has been, that even this poor remnant of the Coal-Measures, where it is left, consists of only the very lowest bed or the two lowest beds of the Coal Measures, the poorest of all the coal beds of the system. Fig. 2 will show how this result occurs :

Fig. 2.

SHOWING THE COAL BEDS LEFT IN THE DOWNTHROW

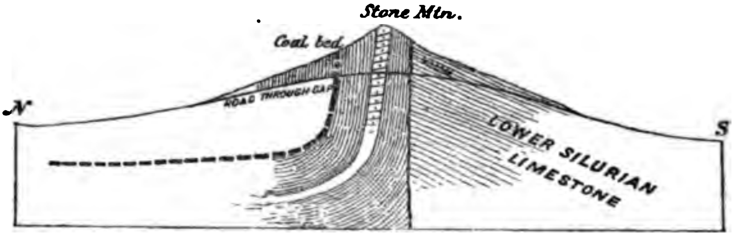


It is not until, going north 30° west, several such downthrows with their comparatively worthless coal fields (so to call them) have been passed, that the real coal field of the country is reached. Its southern edge runs along a straight downthrow lying just north of the Clinch River.

I shall first take up this line at Guest's River, in Wise County, and follow it northeastward, ascending Clinch River ; and I will give sections of its Coal Measures, wherever I studied them.

Stone Mountain, which is the south border of the Guest River Coal Fields, in Wise County, is cut throughby Powell's River at the Big Gap Some miles further east its summit is notched by a wind-gap (Little Gap), through which the turnpike from Wise County Court House (Gladesville) to Scott County Court House (Estillville) passes. The *lowest coal bed* is opened on the side of the road a quarter of a mile before reaching the gap; that is, high up the southern face of the mountain. The coal bed is 4 feet thick, and vertical. The core of the mountain is a vertical Conglomerate Sandrock. On the south face of the mountain are cliffs of Lower Silurian limestone. A fault, therefore, runs through the mountain lengthwise, thus:

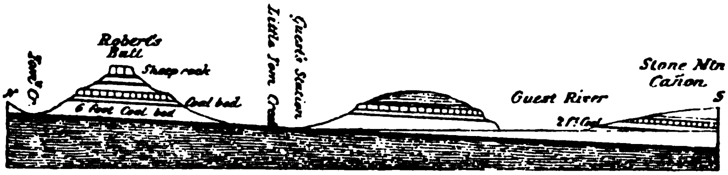
No. 1 SECTION LINE ON THE MAP.



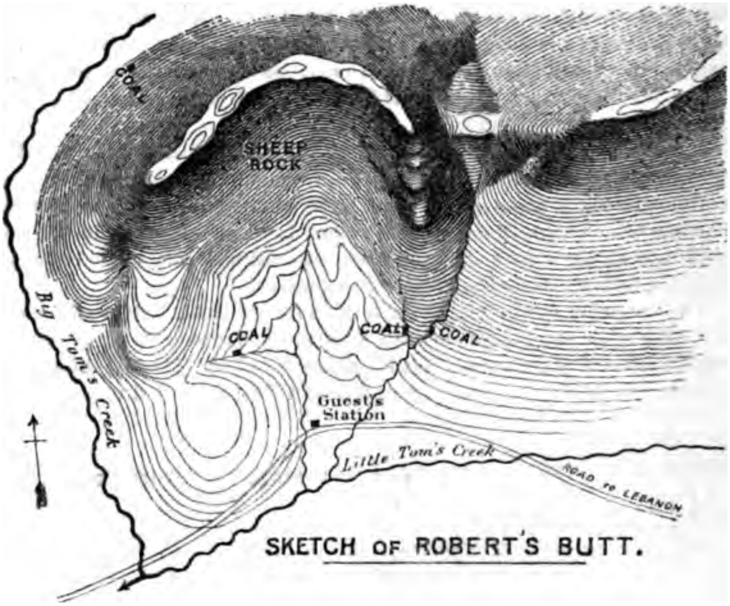
This section, however, I did not myself see; but the information from which I construct it was given to me so clearly, and agrees so exactly with what I saw myself further east, that I have no hesitation in assigning it a place in this report, without endorsing it more specially.

On the west side of Guest River, two miles below the mouth of Tom's Creek, a *two-foot coal bed* is mined; it lies nearly flat, under cliffs of horizontal conglomerate rock. Below this place, the river enters the cañon, through which it rushes for two miles before entering the Clinch River. Vertical walls of conglomerate, hundreds of feet high, stand opposite each other. This is the natural gate for a railway line to the Wise County and Kentucky Coal Field.

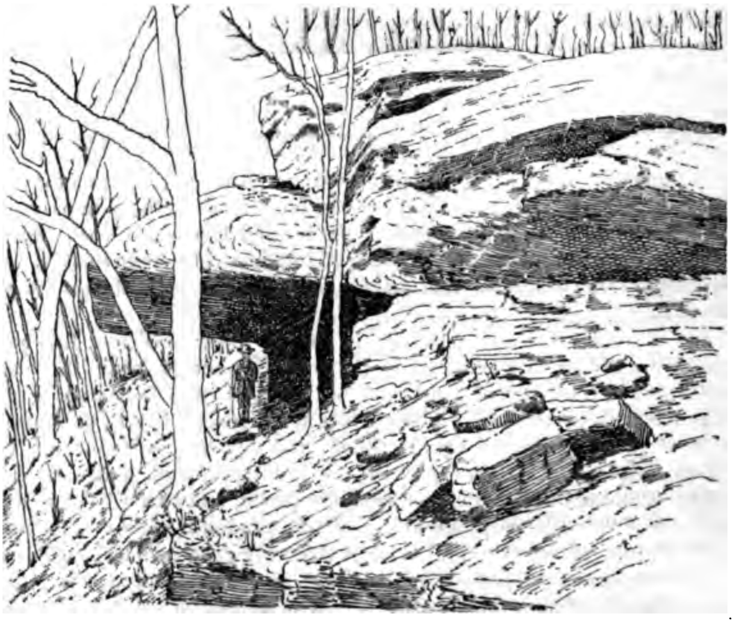
SECTION 2 ON THE MAP.



Coal beds are opened up and down Tom's Creek and its branches. One coal bed, from 5 to 6 feet thick, runs through the bases of all the hills, nearly at water level, and almost horizontal. It is mined for family use in the gulches back of Guest's Station (an old log fort, now a store and, although half a mile from the mouth of Tom's Creek, overflowed whenever Guest River is in high freshet), and by Mr. Jessee, and for several miles still higher up Tom's Creek. It is mined up Little Tom's Creek, and on Crab Orchard Creek, as a fine six (6) foot bed of rather handsome flaming coal, solid enough to wagon over rough roads, and not making much ashes or clinker in the grate. It is at least equal to



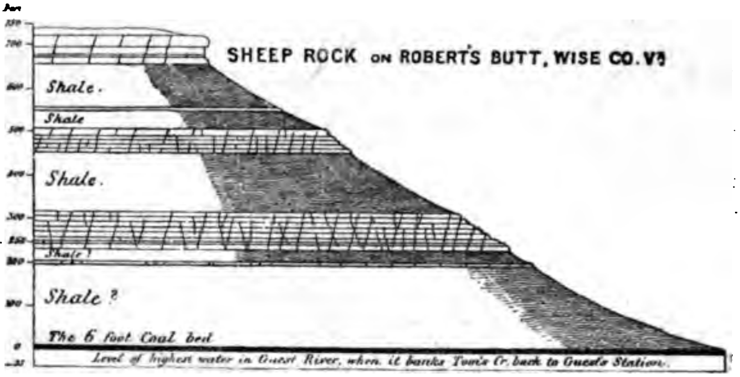
The Great Sheep Rock on Robert's Butt



the general run of the Lower Coal Measure coals in the Bituminous Coal Basins of the Susquehanna West Branch and the Conemaugh. I saw no other beds here; but there must be others both below it and above it; for the beforementioned two-foot bed ought to be above it, as the above section (2) shows.

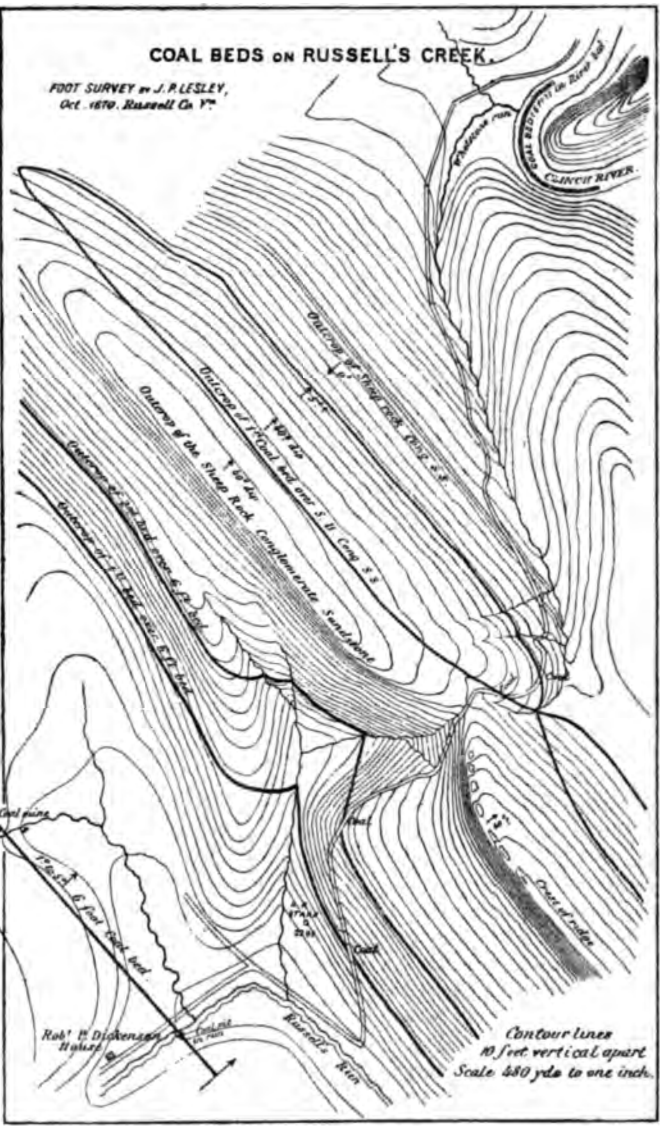
I made a measured section of one of these hills, called Robert' s Butt (over 700 feet high, and capped with a fragment of the great conglomerate sandrock which once covered all the country), as a specimen of the barriers which separate all these streams from one another, in the coal field, and to show how impracticable any railroad line must be which does not follow closely the great water-courses.

The following section up the side of Robert's Butt, half a mile north of Guest's Station, was made with an aneroid barometer. It shows the Sheep Rock Conglomerate Sandstone to be about 700 feet above the (Newberry, Robinet, Grier, Jessee, &c.) Six-Foot Coal Bed :


SHEEP ROCK ON ROBERT'S BUTT, WISE CO. Va
Feet
700
600
500
400
300
250
200
100
0
-35
Shale.
Shale
Shale.
Shale?
Shale?
The 6 foot Coal bed
Level of highest water in Guest River, when it banks Tom's Cr. back to Guest's Station.

At one place where the bed has been dug a little into, it yields the best kind of bituminous coal, fat and caking, but friable, with no appearance of sulphur, and making no clinker. It is good blacksmith-coal, and no doubt will make good coke. A piece of ill-made coke from what is, perhaps, the same bed, near Gladesville, shows that the best coke can be got from it.

On *Russe's Creek* this coal bed is also at water level and has been mined by Robert P. Dickenson in the bed of the creek, near his house, and in a run a quarter of a mile further east, where a horizontal gangway has been commenced. About 5 feet of the coal is visible; the bottom is not reached, being in water. Roof: a shaley clay, without distinct plant impressions. Upper part of the bed bituminous, and somewhat bony. From the first 12 inches downwards, solid, and somewhat like cannel. Coal in some parts slightly granular, reminding one of the sand-coal of Montgomery County. Bottom coal very good for blacksmithing; makes a hollow fire; but cakes little and goes out before morning; not much ashes; ashes white; makes a yellow blaze; no sulphuret of iron visible; no fossil leaves. Streaks of coal through the bed showing numerous minute discs of sulphuret of iron in the fissures; so that an analysis of the bed as a whole will give a notable percentage of sulphur; and it will be extremely difficult to pick the coal, if mined extensively, so as to furnish it free of sulphur. It is, however, on the whole, a satisfactory bed; and its harder benches will bear carriage well.


COAL BEDS ON RUSSELL'S CREEK.

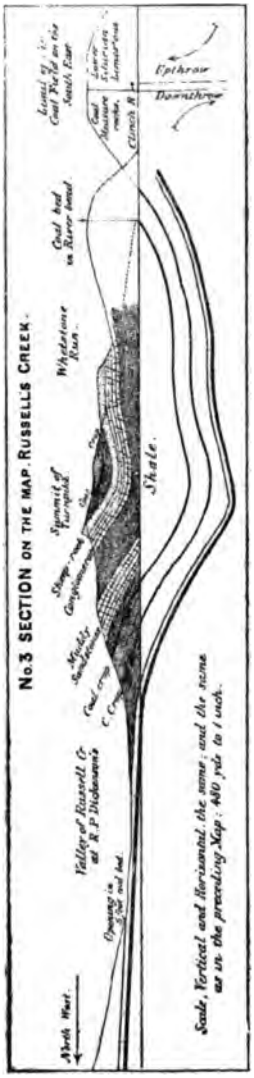
FOOT SURVEY BY J. P. LESLEY,
Oct. 1870. Russell Co. Va.

Contour lines
10 feet vertical apart
Scale 480 yds to one inch.

CLINCH RIVER.
Outcrop of Sharp rock Cong. S.S.
Outcrop of 1st Coal bed over S. R. Cong. S.S.
Outcrop of the Sharp Rock Conglomerate Sandstone
Outcrop of 2nd bed over 6 ft. bed
Outcrop of 1st bed over 6 ft. bed
Coal mine
6 foot Coal bed
Coal
Coal
Crest of ridge
Russell's Run
Robt. P. Dickenson House

The bed dips at least 5° southward at this precise place; but not so much over a larger area. Over it are thin slabs of shaley sandstone, with large calamites and stigmaria stem impressions; and over these again a small coal bed; which cannot lie more than 20 feet, if that, above the other bed.

I made a careful survey of the hill to the south of this place, the summit of which is made by south-dipping conglomerate sandrocks (Sheep Rock of the last section); and found two coal beds outcropping on its north face, and two more on its south face, descending Whetstone Run to Clinch River. This run has a conglomerate terrace on its left bank, and is rendered very rocky by the descent of fragments of rock.



No.3 SECTION ON THE MAP. RUSSELL'S CREEK.

Scale, Vertical and Horizontal, the same; and the same as in the preceding Map; 480 yds to 1 inch.

Section No. 3 on the map is the most instructive I could obtain in this district of the region, and requires no explanation. It shows that the distance from the Six-Foot Bed up to the Sheep Rock Conglomerate is everywhere about 700 feet, and contains at least two coal beds; and that there is one more coal bed above the conglomerate. I had no means of determining the size or quality of any one of these three beds; but they are all, probably, under 3 feet.

The above sketch-map and this accompanying cross-section (No. 3) were measured on the ground and drawn to scale. They enable me to speak of only *one* coal bed above the Sheep Rock Conglomerate, with two outcrops on this road, looking like two coal beds. Further east, as will be seen, this bed (?) has several others over it.

The section renders it doubtful whether the coal dug at lowest water in the bed of the Clinch at the mouth of the Whetstone be the six-foot bed. It looks more like the second bed above it. But the southeast end of the section is a little obscure, and I had no time to study the exact character of the Downthrow of the Coal Measures against the limestones* at this point. It runs through an isolated hill, quite surrounded by a bend of the river, as shown in the sketch-map on the next page.

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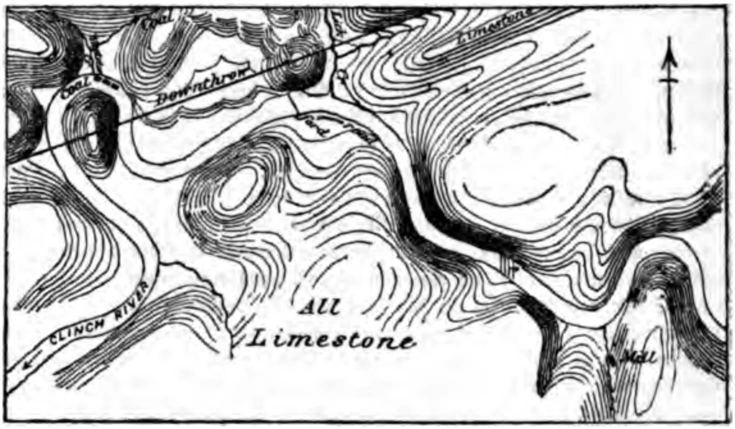
* Query.—Do these belong to an outcrop of the subcarboniferous limestone issuing from the fault?

The map below will give a better idea than any verbal description of the difficult nature of the ground for railroading purposes down Clinch Valley. The hills are from 200 to 300 feet high and present bold and massive cliffs of Lower Silurian limestone to the river.

It will also illustrate the general law that the principal rivers and large streams of this region of Virginia run in the lower members of the Lower Silurian limestone system, as they habitually do elsewhere, near the edge of the Freestone Carboniferous land. The cause of this is evident. The surface of the country as it is at present has been produced by the removal of all the geological formations above that which now forms the surface. When the Downthrows were first formed the drainage of the country was down the face of the Coal Measures to the crack and then along the crack sideways. This produced a very slow erosion of the Coal Measures, because of their numerous massive bed of sandstone. But the drainage along the cracks produced great erosion into the face of the sandy and magnesian limestone exposed by it. The drainage from above also produced caverns in the limestone. Out of these caverns issued streams which swelled the rivers which ran along the cracks. The formations over the limestone were worn rapidly away. The face of the limestone wall of the crack was worn back. And so, by the time the present surface level was reached, the rivers, which originally flowed on the Coal Measure side of the cracks, had got their valley-beds fairly established on the limestone side of the cracks; and, sometimes, at a considerable distance on that side.

SKETCH MAP OF CLINCH RIVER,
where it strikes the Coal Measures and rebounds,
at Lick Run.



As the lower limestones are massive and very soluble all the streams of the region which flow through them have extremely rough and tortuous valleys, walled in at intervals with cliffs. The smaller streams head up in smooth valleys (of the upper limestones and slates of the Lower Silurian system) admirably fitted for railroad locations. But near their mouths, where they cut rapidly down through the lower limestones to flow into the cross streams, their beds are full of jagged rocks and their valleys difficult for cheap railroading.

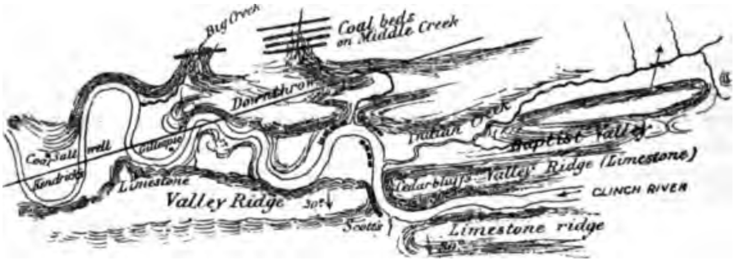
It is among these lower limestones that the beds of *brown hematic iron ore* lie. For instance, the cliff at the river bank, just where the road from the west along the north bank comes to the ford at the mouth of Lick Run, is a mass of sandy limestone, near the bottom of the Lower Silurian system. Further up the north bank of the river, east of Lick Run, is a long limestone hill on which many pieces of the ore are scattered, some of them very large. There is a good chance here for the existence of a valuable iron-ore deposit on a large scale. The ore is good.

THE COAL FURTHER EAST.

I made no detailed examination above Lick Run for a good many miles; and I have mentioned in a Summary Report the streams crossed by the coal beds in this interval. I will only add here, that some of these beds were *reported* to me as ten (10) feet thick. The six-foot bed may become thicker at points which I did not visit than it is where I saw it.

The "Mouth of Indian" is a thriving little village on the north bank of the Clinch where it enters Russell County. I surveyed this neighborhood carefully, because the coal beds here have been opened more extensively than elsewhere; because they stand at a higher angle and give a series; and because the downthrow is exhibited in a most curious and instructive manner. The river breaks through limestone just above Indian Creek mouth, forming bluffs called the Cedar Bluffs. A dam was built here forty years ago out of red cedar logs which has never needed repairs. It is fifteen feet high and backs the water two miles. Middle Creek descends from the north and enters just below Indian Creek.

Up Middle Creek are the coal mines. See the following map:



Two miles further down the river, Big Creek runs across the upper end of the wide and fertile bottom called the "Rich Lands," at the farm of Mr. Gillespie.

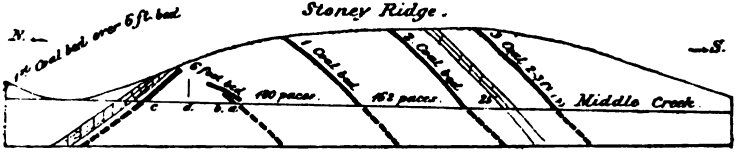
Two miles further west, a salt well, 354 feet deep, was sunk at the north edge of the river bottom, on Mr. Kendrick's land, twenty-two (22) years ago, and, at 337 feet, went through 6.7 (six feet seven inches) of coal. Six feet at the top of the well was mud. All the rest was "sandrock," without coal.

Petroleum.—There was enough oil to grease the rods. The well was plugged up. Recently the plug was knocked out, when *fresh* water spouted from the 3½-inch hole to a height of three feet, but soon subsided. A film of oil stands on the water, which is very cold and too brackish to taste perfectly good, although cattle go to it in preference to drinking other water.

Salt.—The spot selected for the well had been a famous deer and buffalo lick. The ground had been eaten away by the animals. Thirty or forty deer used to be seen at one time at this lick; and spoonfuls of salt could be collected. It must be borne in mind that the salt wells of Eastern Kentucky get their water from the conglomerate at the base of the Coal Measures. There must, therefore, be a saltwater-bearing formation several hundred feet below the coal bed at the bottom of this well; supposing, 1, that it is the Six-foot Bed of Wise County; and supposing, 2, that the Sheep Rock Conglomerate Sandstone is *not* the true Conglomerate Base of the Coal Measures. But even if the latter supposition be wrong, and the Six-foot Bed be one of the Sub-Conglomerate Coal Beds of Eastern Kentucky, which is quite a possible thing, there remains a still lower "Knobstone," or Devonian Saltwater-bearing Formation, from which the salt water must find its way to the surface through the Great Downthrow and cross-fissures connected with it. This Devonian Saltwater-bearing Formation is that which supplies our deep salt wells in Western Pennsylvania, and is also the same as the Petroleum-bearing Formation of Venango County.

THE COALS AT MOUTH OF INDIAN.

(Section No. 6 of the Map.)

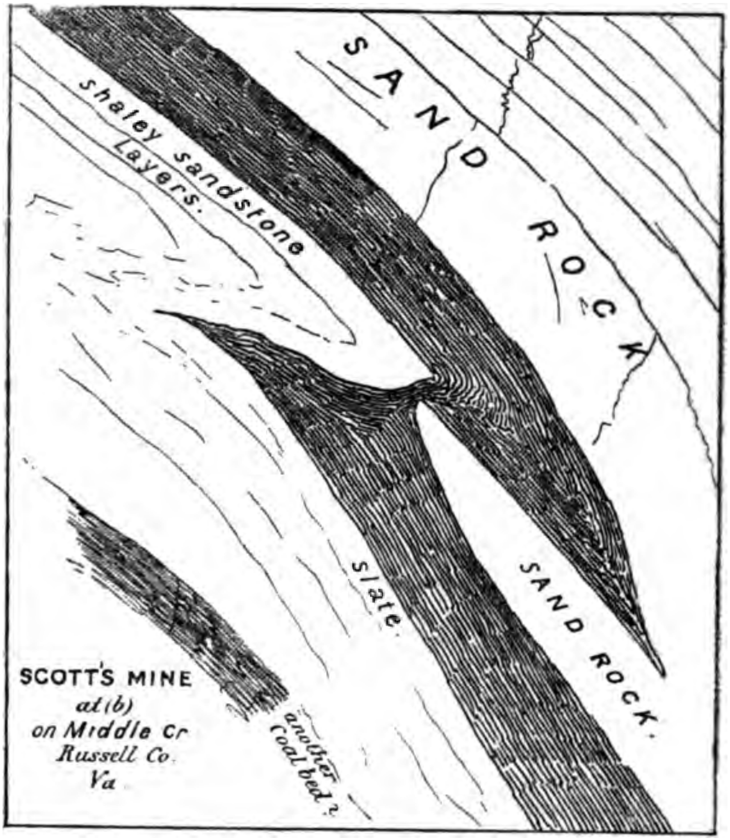


The Six-foot Coal Bed, here, has been opened and mined for the use of the neighborhood by Mr. Scott, at (*a*) about 1½ miles up the creek from its mouth; and again at (*b*) a quarter of a mile further up, on the same south dip. At both (*a* and *b*) it shows a disturbance represented in diagram on the next pages.

The bed is here, really, but 2½ to 3 feet thick. It is covered with a plate of sandstone which is several feet thick; and, although the pressure produced by the Great Downthrow, which runs along at a distance of about half a mile due south of the locality of the mine, has folded the coal bed *with* the sandrock back upon itself, yet the sandstone of the rock, thus caught in between the walls of the fold of the coal, is perfectly solid and does not show the slightest trace of disturbance. This is a striking, but well-known phenomenon. The coal itself is bent round, and shows sharp tongues, in the fold.

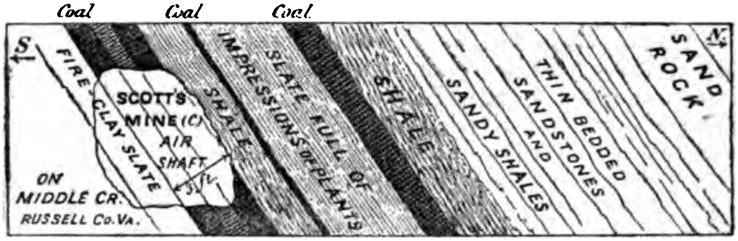
At (*b*) the same sandrock is equally folded and unbroken, as the following diagram (looking in the opposite direction, *i. e.* east) will explain.

Here, also, the bed, which when doubled measures 5 or 6 feet thick, is really but a three-foot bed. There is nothing, in fact, to identify it with the "Six-foot" coal of Wise County. But it may very well be the 6.7 coal of the Salt Well, three miles distant.

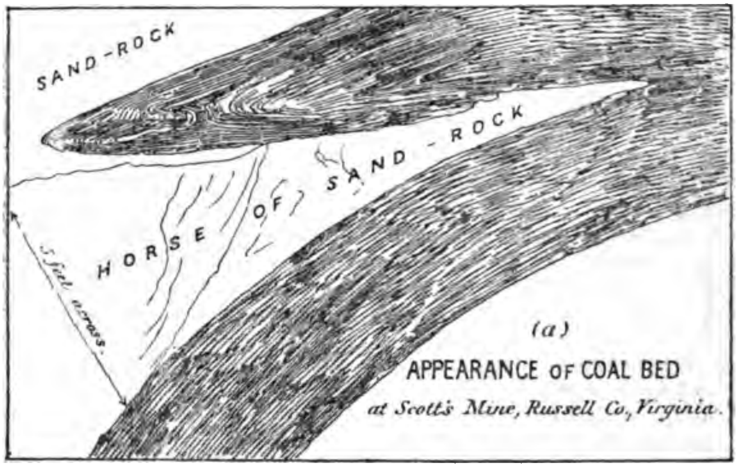


It is opened again at (*c*) some hundred yards higher up the creek, and on a *north* dip of 50°. The Confederate army mined it pretty extensively. It is here three feet thick, in three benches each a foot thick. The top and bottom benches good, the middle bench bony. Over it are three or four feet of slates, and then comes a one-foot bed of bony coal. The report goes that the miners found these two coal beds close together, down below ; making thus one very fair *four-foot coal bed.* A diagram on the next page shows the whole exposure in position.

All this is not very encouraging for the coal trade. But the same bed has been opened at (*d*), directly on the crest of the anticlinal, which has here sunk (running in an easterly direction) to the level of the creek. Here the coal lies flat in the water; and several pits, sunk through it, are deeper than the height of a man. The bed must be nearly, or quite, six feet, and yields good coal (as indeed it does at the other openings); but what its constitution may be I do not know. It is probably subdivided into benches of different qualities; and, no doubt, has some of the slate of the above last section running through it. Its position on the anticlinal will make mining difficult.



The anticlinal disturbance at Scott's Mines on Middle Creek must be local; because the topography around the Salt Well shows that the Coal Measures *there* come up to the Downthrow in a flat and undisturbed condition; and the dying down of the crown of the anticlinal in the Six-foot bed so rapidly that the bed lies flat in the creek only a few hundred yards above where it plunges at angles of 40°, 50° and 60° proves the same thing.

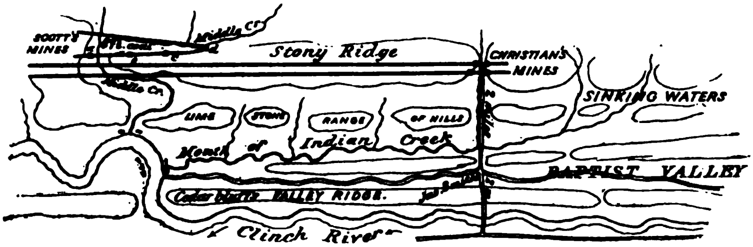


(a)
APPEARANCE OF COAL BED
at Scott's Mine, Russell Co, Virginia.

Nevertheless, the very steep dips of the overlying coal beds and rocks throughout the body of Stony Ridge makes the whole disturbance of considerable magnitude; and I have no doubt that when it is well examined to the eastward, it will be found to run in that direction some miles; not, perhaps, as an anticlinal but as a downthrow; and it may very well be the Abb's Valley Downthrow, of which more hereafter.

LAUREL RUN COALS.

Leaving the curious topography of the Big Creek, Middle Creek, and Mouth of Indian Downthrow to be described hereafter, in connection with Paint Lick Mountain and its Iron Ore, and going east up Indian Creek Valley, I can only report coal mines on Laurel Run, a side branch coming into Indian from the northwest. Mr. Christian has here opened several beds, one of which is reported to be *much over* six feet thick. The coal is wagoned to the county-town of Tazewell, Jeffersonville, fifteen or seventeen (15 or 17) miles distant. The following sketch will show how the coal comes out to market—two miles to James Smith's, on the Baptist Valley Road (beautifully engineered, at low grades), formerly a turnpike, and still the highway between East Kentucky and Middle Virginia; two miles to the Clinch Valley Road; thirteen miles by either of these two roads to Jeffersonville:



What the character of the Christian Coal is I do not know by personal inspection; but it must come from the same beds, and be essentially similar to the Scott Coals, and also to the Abb's Valley Coal next to be described.

Just east of the Christian Mines runs a limestone valley, along the south side of the Downthrow, in which the waters sink into caverns. It is called "Sinking Waters." Any one familiar with Abb's Valley (15 miles further east) will see at once, that the formation is the same; but I will show that Stony Ridge separates the two valleys and that the coal areas which I have been following all the way from Wise County are cut off, or whittled down to a fine point, opposite Jeffersonville. The next cross-section, No. 8, will show how this is done, and also how the Abb's Valley coal beds are brought down to the present surface by quite a different Downthrow from the one we have been tracing thus far, all the way from Guest's River in Wise County; a Downthrow *behind* and to the *north* of this one; as the map in colors will also help to show.

The Clinch Valley Downthrow, going east from Indian Creek, catches in its jaws a less and less number of beds and width of coal ground, until at last, on crossing the great road from Jeffersonville north to Tug Fork of Sandy, it holds but the lowest coal bed, standing at a high angle and very little of it left.

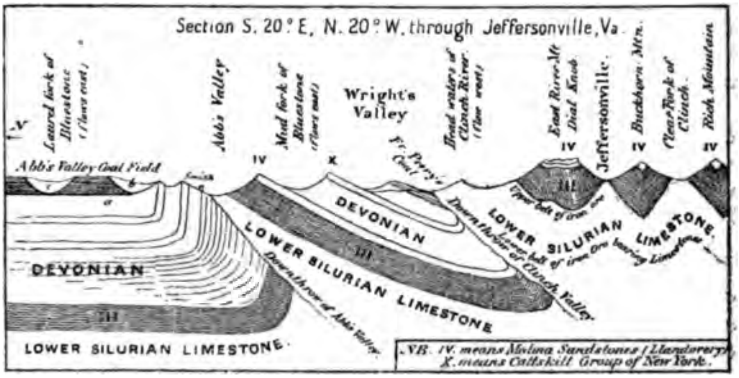
This is seen on the Section No. 8, marked Captain Frank Peery's Coal. How far east along this crack this coal can be traced. I do not know; but nothing of value can be expected from it; which is a great pity; for at this point *easy* access to the back country ends.

To get over into the Abb's Valley Coal Fields, two mountains must be crossed, or, rather steep stony hills, consisting of all the formations from the coal down to the limestone; especially Sandrocks X (Catskill) and IV (Shwangunk) here much diminished in thickness; which accounts for the comparative lowness of these mountains when compared with the high mountains formed by the increased outcrops of these formations in the Northern States.

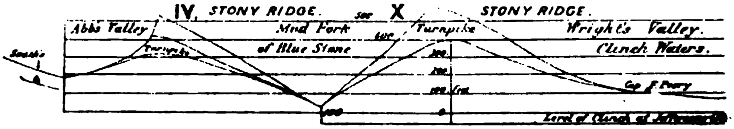
The deep rapid rocky bed of Mud Fork of Bluestone lies between the two mountains and descends eastward. Where the turnpike crosses it it is 400 feet below the notch in the crest of the first mountain, X (say 350 feet below the crest itself); and 250 feet below a slight notch in the crest of the second mountain, IV. This crossing of Mud Fork is, by barometer, on a level with the Jeffersonville Court House, and about 100 feet higher than the Clinch two miles east of Jeffersonville, at the west end of Wolf Creek Valley.

(Cross Section No 8, on the Map)

SHOWING THE ABB'S VALLEY DOWNTHROW.


Section S. 20° E, N. 20° W. through Jeffersonville, Va.
IV
Laurel fork of Bluestone (flows east)
Abb's Valley Coal Field
Abb's Valley
IV
Mud fork of Bluestone (flows east)
X
Wright's Valley
Fr. Peery's Coal
Head waters of Clinch River (flow west)
East River Mt Dial Knob
IV
Jeffersonville
Buckhorn Mtn.
IV
Clear Fork of Clinch
Rich Mountain
IV
III
Upper belt of iron ore
DEVONIAN
LOWER SILURIAN LIMESTONE
III
Downthrow of Abb's Valley
DEVONIAN
Downthrow of Clinch Valley
LOWER SILURIAN LIMESTONE
Lower belt of iron ore bearing Limestone
DEVONIAN
III
LOWER SILURIAN LIMESTONE
NB. IV. means Medina Sandstones (Llandovery)
X. means Catskill Group of New York.

The turnpike summit crossing the first mountain (X) is 300 feet above Captain Frank Peery's, on the head-waters of Clinch (6¼ miles north of Jeffersonville). Clinch and Bluestone run in opposite directions along Wright's Valley; Clinch westward, Bluestone eastward. The divide between them is about 1¼ miles east of the turnpike, at Frank Peery's, and say 100 feet higher in level. This route from Greenbrier to Tazewell is feasible, but it is needless to try to get coal out that way.



Mud Fork of Bluestone heads up rapidly westward of the turnpike, and yet the valley between X and IV must continue on between the two Stony Ridges from the very necessities of the case.

Abb's Valley is produced by a great upthrow of the Lower Silurian limestone against the Coal Measures. The turnpike enters it almost at its head, or western end. From the notch in IV through which the road passes, to the Dry-water course in the centre of the valley is a descent (by barometer) of only 110 feet. Westward the valley rapidly fills up, and that is the course to take in locating a railroad from the mines out to Jeffersonville. A feasible route may be obtained, I think, by keeping up Abb's Valley to and over its divide, and down Cavitt's Run to the Clinch. two miles west of Jeffersonville.

The cause of the heading up of Abb's Valley and Mud Fork Valley so suddenly westward, and against what seems to be the main body of the Tug Fork of Sandy Coal Measures, is a most interesting and important affair, which should be investigated. I can only conjecture it. I take it to be likely that the Abb's Valley Upthrow of limestone starts across the Measures southwestwardly, becoming less and less of an upthrow, and thus swallowing down from the surface first, the Lower Silurian limestones of Abb's Valley, and then the shales and sandstones of the two stony ridges IV and X; and that it finally merges in the Clinch River Upthrow. At all events, such a geology would result in a topography of this sort: The limestone and shale valleys would head up suddenly against a ridge composed of Coal Measures Conglomerate or Sandrocks.

My advice is, that no coal-freight railroad line be sought for in the direction taken by the Jefferson and Tug Sandy Turnpike. But, on the contrary, that a line be sought further west, more down the Clinch, viz.: up Cavitt's Creek. Let the coal beds there be carefully explored, and a line be found across the divides beyond the west line of Abb's Valley.

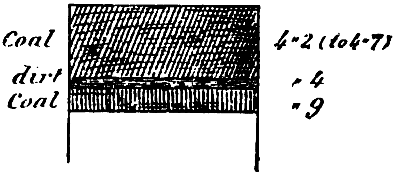
ABB'S VALLEY COAL.

Fifty feet below the summit of the hill, shown in the "Local Map" on the next page, and nearly 150 feet above the coal bed at its base, is a layer of very coarse, gray, friable sandstone, weathering yellow, without pebbles. Over it a tree has turned up a coal crop.

The coal bed below is, perhaps, the only workable bed of this district. For, after descending, at a slope of one or two (2°) degrees, south 20° east, through the base of the hill, and getting under water level, it seems to turn up suddenly and quite vertically, and to outcrop along the bottom of a little valley. It has been mined a little close to the turnpike (*b*) and Mr. Smith reports it to be "as wide as a room."

Ten miles east of this, and in a similar position, a coal bed is mined, which I judge to be the same one, and it is called ten (10) feet thick.

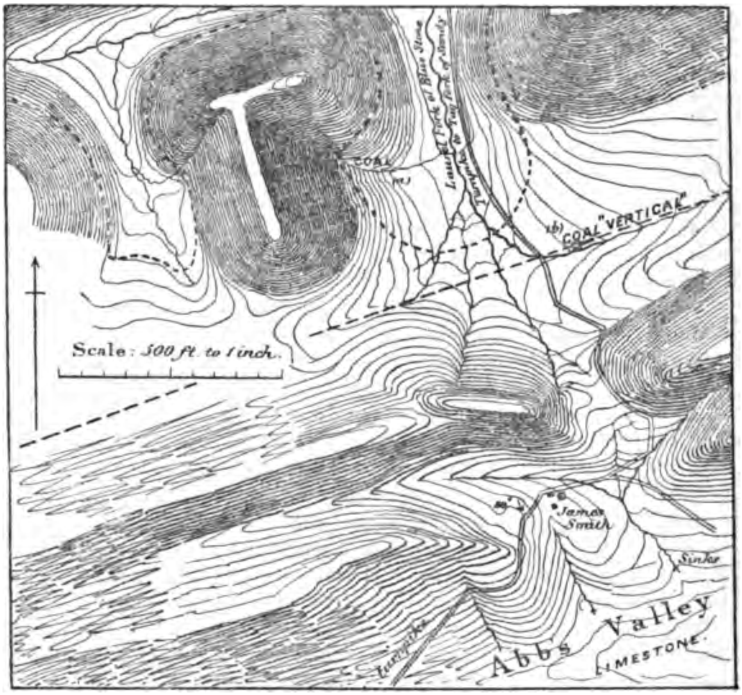
In the openings at the foot of the hill (at *a*) it has been merely thrown out from the water of the little brook. Mr. Cochrane, who has dug coal all through this region, gives its thickness as (5) five feet of coal in $5\frac{3}{4}$ of space. A dirt bed, four inches thick, separates the lower bench of very fine coal from the upper and main body of the bed.



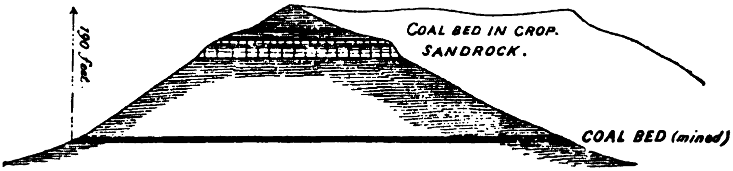
This coal bed is dug into by the farmers, at several places on the hill-sides of Laurel Fork, from half a mile to several miles north of Smith's coal. It is called six feet thick. Cochrane says he has dug it on Laurel where it was good seven feet.

LOCAL MAP OF ABB'S VALLEY COAL.

(Properly Blue Stone Coal.)


COAL
(a)
Laurel Fork of Blue Stone
Turnpike to Tug Fork of Sandy
(b) COAL "VERTICAL"
Scale: 500 ft. to 1 inch.
James Smith
Sinks
turnpike
Abbs Valley
LIMESTONE.

CROSS SECTION OF COAL IN HILL.



The level of the coal opening is (by barometer) 115 (one hundred and fifteen) feet above Smith's house; which house is 125 feet below the summit of turnpike crossing, Stony Ridge (No. IV). [See p. 504.] The coal and the turnpike summit are, therefore, nearly on a level.

From these coal outcroppings just back of Abb's Valley the coal field of West Virginia and Eastern Kentucky extends, without a break, to the Ohio River. And the south edge of this coal field is the north ridge of Abb's Valley. The coal beds can be opened anywhere in the hills, just north of Abb's Valley ; and several low windgaps, similar to that at Mr. Smith's, give the people of the valley access to the coal field. But, as I have said before, the railway line which passes through Tazewell must approach the coal field from the west—not from the south ; around the head of Abb's Valley, from Cavitt's Creek. This will also subserve the interests of any railway projected from the Ohio River up Tug Fork of Sandy to Jeffersonville.

(N. B.—I do not feel entire confidence in my geology of the sandstone ridges at Smith's,—the ridges which form the north boundary of Abb's Valley. They need much more careful study than I could give them.)

THE IRON ORES OF II AND V.

The valleys of Tazewell and Russell, in Virginia, being geological, as well as geographical, prolongations of the interior limestone valleys of Pennsylvania, such as the Nittany, Morrison's Cove, and Kishicoquilis, contain necessarily the same kinds of ore, in the same formations, and in the same conditions. I mean that the unbroken ground is at present covered with patches of brown hematite "blossom," just as the ground used to be where our charcoal furnaces stand ; and that the color of the road and field soil is the same as that of our best iron ore banks ; the limestone rocks project in the same style, have the same internal composition, and exhibit the same corroded and dissolved surfaces ; and potholes, caverns, and sinks abound along certain lines of outcrop. All these things are now known to bear an intimate relationship with both the original setting free of the mineral iron from the limerocks, and its subsequent deposit and consolidation. And it seems to be becoming clear to our geologists, that while there are regularly stratified beds and belts of the ore at two or three distinct horizons in the Lower Silurian Limestone Formation, which may be traced for many miles along the strike of the rocks, there are also vast accumulations of this brown hematite ore along anticlinal axes, especially wherever these are fractured ; or degenerate into pure upthrow faults. It stands to reason that such a line of fracture, with a high wall on one side of it, should, in the course of thousands of ages, have collected vast quantities of the peroxidized iron which was being, through all these ages, set free in the slow dissolution of the limestones and the reduction of the whole mass of upheaved country to its present level. To say nothing of the facility afforded by such fissures to the decomposing and recomposing agency of drainage waters.

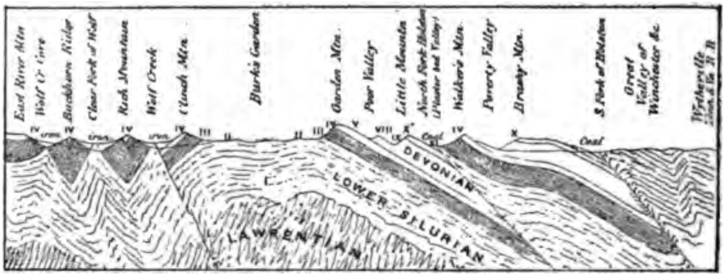
It is along the great upthrow fissures, then, that we are first to seek the iron ore deposits of this section of Virginia. And such a spot was pointed out to me near the mouth of Lick Run, on the hills bordering the north bank of the Clinch River, in Russell County, at section line No. 4 upon the map. Large masses of "blossom" lie scattered about the fields.

Similar shows of ore occur in other places. The hills southeast of Jeffersonville, just outside the town, show the existence of ore beneath the surface. Great quantities are reported two miles east of the town; and still more abundant exhibitions in the cove of Wolf Creek, behind Buckhorn Ridge, north of the forks of Wolf Creek, and opposite Rocky Gap. Immense shows are reported in Wolf Creek Valley, inside of (or south of) Rocky Gap.

I have myself no doubt of the correctness of these reports, so far as surface exhibitions are concerned. And it is an old and good iron master's maxim, that where there is plenty of blossom there will be plenty of good ore. The fact is geologically exact. For the blocks of ore on the surface of limestone land (like the masses of white quartz on the surface of a mica slate country) are the undissoluble parts of the original country left behind by the slow and imperceptible mouldering away and removal of the softer material.

A downthrow fissure, also, traverses Wolf Creek, at the foot of Clinch Mountain, as shown in the following continuation of section 8, and this fissure brings the No. IV sandrock of the mountain (which surrounds Burke's Garden) at a dip of 30°, down against the limestone of the valley. How far this fissure extends eastward I do not know; but certainly beyond Rocky Gap.

CONTINUATION OF SECTION No. 8 (OF THE MAP) SOUTHWARD.



There is also a sharp, broken anticlinal axis running through the valley of the Clear Fork of Wolf Creek, and this would favor the accumulation of iron ore. Another traverses the cove behind Buckhorn Ridge, cutting it off from East River Mountain. It is on this anticlinal that the Wolf Creek Cove ores exhibited.

But there is another important fact not to be lost out of view. Throughout Southern Pennsylvania, and as far eastward (along the belt of which we are treating) as the Lehigh and the Delaware, and so on through New Jersey in the one direction, and through Maryland and Virginia in the other direction, the horizon (or formation level) of the bottom of the Lower Silurian (formerly called "Hudson River") Slates, No. III, and the top of the Lower Silurian Limestones, No. II, is a plate of brown hematite iron ore-bearing rocks. Many of our best and oldest mines, like the Balliott and the Moselem, between the Schuylkill and the Lehigh, are on the outcrop of this horizon, at the top of the limestone formation. Where the dip is low and the slates of No. III are thick, this line runs through the middle of our limestone valleys. Where the dips are steep and the Slate Formation No. III is not so thick, the latter forms the flank of the mountain, and the iron ore line runs at the base of the mountain. Where a closely folded anticlinal makes the valley so narrow that the two bases of the opposing No. III Mountains touch each other, and the ridge of the limestone formation No. II, juts up along the water course, or does not quite come to the surface (as in the three valleys at the left hand side of the above Section No. 8), the iron ore deposits must be abundant.

Holding these simple principles of structure in mind, it is evident that the great iron bearing formation, at the base of the No. III Slate Formation, keeps its character all through Middle and Southern Virginia, and will be as rich and certain a basis for large iron mining and iron smelting operations as any other and better known section of the Appalachian Mountain Belt between New York and Alabama.

An old forge at the west end of Paint Lick Mountain (between Lebanon and Jeffersonville) used this top-limestone-horizon ore; and I have no doubt of its abundance in many other places. It is more constant and regular than the ores further down and near the bottom of the Limestone Formation No. II. And these, moreover, are often swallowed up to such a depth by the downthrows as not to be attainable for many years.

It remains to notice a quite different variety of iron ore, which, I hope, will prove sufficiently abundant at a few points along your line of road. It is the Fossil Ore of V; the Paint or Dye-stone Ore of Tennessee.

To describe the situation of this ore, I must refer to the map accompanying this paper. I have colored Formation No. V, the red shales of the Clinton Group, with the color which I gave it on the State Geological Map of Pennsylvania. This color, however, is not appropriate to the formation in Southern Virginia; for the *red soil* and *reddish* (Upper Silurian) *sandstones* which mark the slope sides of our Pennsylvania Mountains (of No. IV), gradually disappear as one goes south from the Potomac, giving place to a gray soil and very slightly, often not at all, reddened sandstones and slates. On the other hand, the opposite side of the mountain, where the basset edges of the (Lower Silurian) slates of No. III crop out, is very red. A Pennsylvanian geologist floating over the country in a balloon would naturally make the mistake of just reversing the geology of the mountain, and would descend upon the wrong side of it to seek for the well-known and highly prized fossil ore bed of Danville and Frankstown.

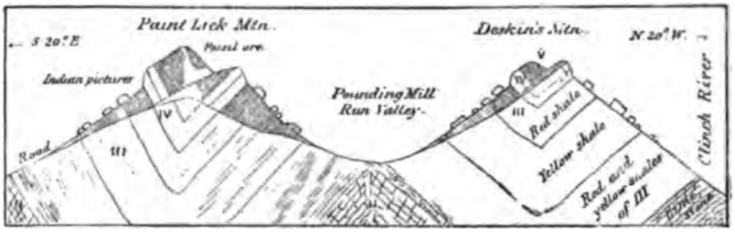
In spite of this change of color in the formation soils of the region, I have thought it best to retain the red color for No. V upon the map, seeing that it represents the blood-red color of the fossil ore itself. One may see, then, by tracing the lines of color on the map, where the fossil ore bed *ought* to be; whether it be there or not. Very extensive and costly explorations have been necessary in Pennsylvania and Maryland. No doubt much research of the same sort will be called for in Virginia. But the ore is there; and, as in Pennsylvania and Tennessee, it will run for miles together in a workable condition as to size and posture, and prove a source of wealth.

The principal use of this ore is to mix with other varieties,—with the blue carbonate lean ores of the Coal Measures, especially; but also with the inferior grades of brown hematite. The time will come when it will be smelted in connection with the primary ores of the Blue Ridge Range and Smoky Mountains.

The forge which stood many years ago at the west end of Paint Lick Mountain, in Russell County, used this ore, and obtained it from the summit of Short Mountain to the south.

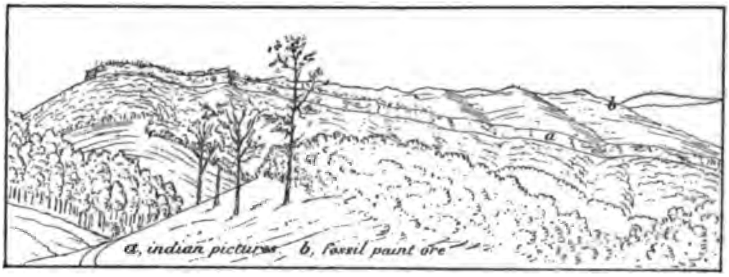
Paint Lick Mountain is named from an exposure of this ore on its summit. The situation is one of peculiar interest to the geologist and to the antiquarian.

CROSS SECTION AT THE ROAD FROM THE CHURCH TO CLINCH RIVER ABOVE CEDAR BLUFFS; AT LYLE'S GAP.

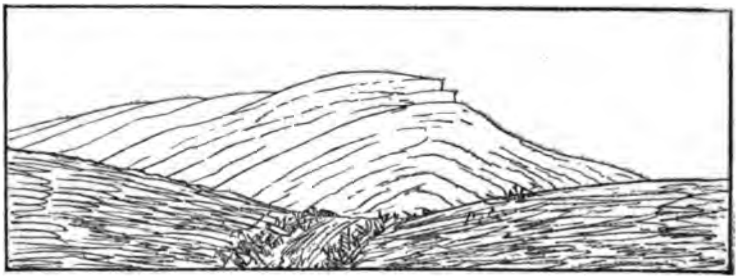


A cross-section, at the road over the mountain, through a notch called Lyle's Gap, will show the cause of the appearance of this ore in so singular a position. It is confined to the very summit of the mountain for some distance midway between the two ends, and to the west of the place where the road crosses. Its thickness and extent is unknown, nor do I think that more than a few thousand tons of it are to be expected. The ore stratum has been swept away from all other parts of the ridge of the mountain, and no trace of it has been left upon Deskin's Mountain; from which, indeed, the great sandrock No. IV has almost disappeared; a few house and barn-like masses being left standing at its western end in most picturesque style. House and Barn Mountain is a prolongation of Paint

PAINT LICK MTN, FROM THE SOUTH; CLIFFS AND ORE.


b
a
a, indian pictures b, fossil paint ore

Lick synclinal westward and is named from two masses of No. IV, left upon its summit, visible from all the surrounding country. Dial Knob (East River Mountain) and Buckhorn Mountain are prolongations of Paint Lick and Deskin's synclinals, eastward beyond Jeffersonville, and Dial Knob may have a good deal of fossil ore left upon it in the cove, behind the Dial Cliffs; but Buckhorn has lost the ore. So has the whole range of Rich Mountain, from Rocky Gap west, to Morris's Knob, which is terminated by one of the most remarkable cliffs of No. IV I ever saw (see its profile below). Short Mountain is a prolongation of Rich Mountain westward, broadened by a shallow synclinal which must hold large quantities of the fossil ore. The synclinal of House and Barn Mountain is prolonged westward (past Lebanon, far down Clinch River) as a downthrow of the No. V Formation against the limestone of No. II; and all along the south side of Copper Ridge there runs a south dipping plate of the fossil ore, which has been opened, in old times, at one point, and used in a now abandoned forge. There must be immense quantities of the ore in this ridge. It is known to the inhabitants, however, only as a paint. But this will be a sufficient guide to the iron master.



DOUBLE ESCARPEMENT OF No. IV. 200 Ft. WALLS,
at the Westend of Rich Mountain, Morris Knob, Russell Co, Va.

The Indians used the outcrop of the fossil ore bed to paint their faces and lodges. The deposit on Paint Lick Mountains was a famous locality among the Aborigines. On a smooth perpendicular wall of sandstone, facing southward, and visible from General Bowen's house and the Maiden Spring, there remain numerous pictures and symbols of men and animals in red paint, fresh as when first made, and older than the settlement of the country by the whites. I give above a view of this long wall of sandstone cliffs as I saw it from the Lebanon-Jefferson turnpike; and, when taken with the cross-section, it will explain without further words both the structure of this (and other similar mountains) and the cause of the small amount of fossil ore left upon its summit, and the total disappearance of the last remains of the ore deposit from the summits of House and Barn, Desmit, Buckhorn, and Rich Mountains.

But there are extensive outcrops of the fossil ore of No. V along Poor Valley; in fact the deposit (whether rich or not remains to be discovered) runs uninterruptedly more than a hundred miles in an almost mathematically straight line along the south flank of the Clinch Mountain from

Tennessee, past Moccasin Gap, back of Saltville, past Sharon Alum Springs, to Hunting Camp and Kimberling Creeks, and so on, eastward, across New River towards the James River country. No doubt some sections of this line hold the ore bed in a lean and, perhaps, unworkable condition; but it is quite incredible that other sections will not have it both thick and rich.

Now it is along this Poor Valley and its outcrop of iron ore that Gen. Haupt locates the line of railway.

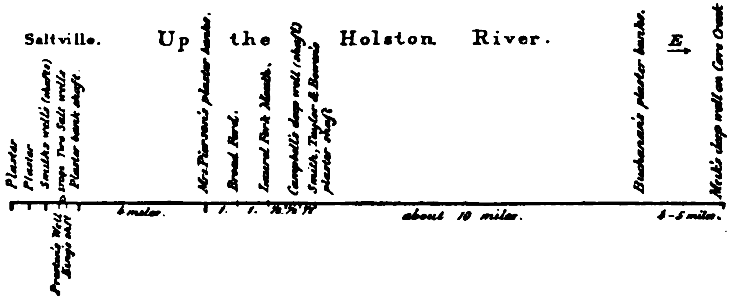
Even if the Clinch River line be adopted, for the sake of the coal and for other reasons, a branch road must certainly be made up Hunting Camp Creek to the Plaster Banks, at Saltville; and this branch will have the ore crop of Poor Valley, and the ore deposits of Tumbling Run, on top of Short Mountain, at its command. It can bring the fossil ore forward to the Forks of Wolf Creek, where are the before mentioned large deposits of brown hematite ore; and where it will meet the coal coming across from the Clinch River. Here, or somewhere lower down Wolf Creek, perhaps at its mouth, will probably be located one of the principal future iron-works of Southwestern Virginia.

THE PLASTER (GYPSUM) BANKS, AT SALTVILLE.

A sound theory of the origin of the gypsum can be, for the present, our only guide to a correct estimate of its quantity, where it is known to exist, and to its discovery elsewhere.

Gypsum may be produced by the action of free sulphuric acid on limestone; or by the action of sulphuretted hydrogen gas on limestone. One or the other, or both of these agents combined, have acted on the limestone rocks along the banks of the N. Fork Holston River, from Saltville, eastward for a number of miles, converting them into gypsum. The acid, whether in a fluid or in a gaseous form, has undoubtedly passed along between the walls of the great fissure which has thrown the Lower Coal Measures of the Poor Valley (Little) Mountain 15,000 or 20,000 feet down against the limestones; has soaked into the walls of the fissure; and has changed the limestone to gypsum for many yards on each side of the crack. Shafts have been sunk through solid masses of gypsum rocks thus formed to a reported depth of 500 and 600 feet, finding no bottom to the gypsum.

The story of this shafting as given to me by General Bowen is as follows:



Captain Smith and his son-in-law Mr. Robinson many years ago sank a line of shafts across the (tertiary or postertiary) plain on which Saltville stands, and *all of them* through gypsum *all the way down.* Others were sunk by Smith & Robinson, Campbell, Taylor & Bowen, Meik and others at other places in the Holston Valley for a length of twenty (20) miles, more or less, and up Cove Creek four or five miles still further east. No attempts were made to get the plaster further on towards Sharon Alum Springs; but there is nothing to intimate its non existence except the absence of outcrops through the soil. These outcrops naturally existing, or accidentally exposed in farming, or by the railroad cuttings south and west of the village, have alone (as it seems) determined the search after gypsum in the valley. And as the Saltville people alone have any proper machinery for sending it to market, a stop has been put to all exploration elsewhere.

Moreovor, seeing that Capt. Smith struck a copious brine in two of his wells, the opinion early prevailed that the salt and the gypsum were geologically connected. This opinion induced a number of persons to sink *in the gypsum outcrops* not for gypsum but *for salt water.* As salt water was obtained in no single instance other than Capt. Smith's two wells, all hope of obtaining brine and making salt elsewhere than at Saltville has been long since abandoned; and consequently all exploration of the gypsum rocks, which had no commercial value to the salt-well borers.

It is therefore probable that the limestone wall (the south wall) of the Holston River Downthrow (Upthrow of limestone) will in course of time be discovered to be converted into gypsum at other points besides those specified above; and that the gross quantity of gypsum existing beneath the surface along this part of the Holston River far exceeds any estimate which I can make from the gypsum banks already opened. And for the same reason it is probable that the limestone walls of the other Upthrows of the region will be found turned into gypsum, at least in certain places, and in very considerable abundance.

The appearance of brine in such quantity and of such strength must be considered as a local phenomenon explainable without reference to the gypsum. Such an explanation may be found in the very curious lake-deposit of the little triangular plain of Saltville; a deposit evidently made in a deep little lake or pond basin filled with red mud saturated with salt-water, gypsum drainings, &c., &c. In this mud the salt-water has deposited rocksalt, and from this rocksalt deposit now rises the copious discharge of brine which furnishes all the supply needful for the extensive salt works. The salt lies in solid form, mixed and inter-stratified with compact red marl or clay, 200 feet below the water-level of the Holston; and the borings have gone down (at the Salt Works) 176 feet further without reaching the bottom! On the top of the deposits of salt and mud is a stratum of blue slate more than 100 feet thick. Over the blue slate lie 60 or 80 feet of gypseous clays. The limestone country being cavernous to great depths, and especially along the face of the Downthrow, it is not surprising to notice that the level of water stands the same for all the wells and shafts sunk at Saltville and rises and falls in sympathy with the Holston River. This accounts for the inexhaustible supply of liquid. The heaviest pumping has no perceptible effect in lowering the level.

In 1853 the salt yield was 300,000 bushels; 50 lbs. to the bushel, and 6 bushels to the barrel; at 50 cents a bushel. Five furnaces were then running 24,000 gallons of brine pumped daily; 10,000 cords of wood burned yearly.

During the Civil War, four wells were pumped night and day for six months, and yielded 1,000,000 bushels of salt during that half year. There were then sixty-nine different "blocks of kettles" going. These kettles, broken and rusty, lie scattered about the valley for six miles, half buried in piles of burnt and broken down walls which represent the various works then in full operation. Some of the salt water was carried in railway tanks nine miles to Glade Spring Station on the Virginia and Tennessee Railroad, and boiled there.

At present there are three "blocks," of 80 kettles each, (5 bushel to a kettle) per 24 hours, making 360,000 bushels per year, of 300 days.

Preston's gypsum banks yielded 2000 tons in 1854; the cost at the mines, in lump, being $3, and in flour $5; eighty miles distant $20.

What the yield has been since and what it is now, I do not know. Operations are vigorously carried on at four or five shafts. Plaster is now sold at the mines for $2.50 the ton; at Sharon Alum Springs, 35 miles to the eastward, at $10, in wagons; and is carried forty miles further east for use upon the soil. Its virtues are well known and highly prized. It *doubles* the grass crop and grain, and greatly improves corn. One bushel of 100 pounds is sown to the acre.

A railway from Saltville east would find a market for all the plaster it carried. Plaster would go east to the Wolf Creek Fork Junction, and return by the other line to be used on the pasture lands of Tazewell and Russell and Wise Counties. But its greatest commercial outlet would be towards Staunton and Winchester.

Although the gypsum rocks have not the regularity of a coal bed, and some difficulties, of a kind peculiar to this district will be encountered when mining operations are extended to cope with the demands of commerce along a great trunk railroad, yet I see no practical limit to the capacity of the gypsum belt for exploration. Shafts five and six hundred feet deep have permitted the miners to feel the gypsum masses for fifty yards in width. Such a mass, limited by such a shaft, weighs six or seven hundred thousand tons, provided the gypsum be solid the entire depth of the shaft, &c., &c. This is not the case; neither, on the other hand, is the *width* of the column of gypsum limited to fifty yards, or to any other figure. Nothing can be more irregular than the masses of gypsum underground—unless it be the course to be taken to get it out to the surface. In spite of all mining difficulties the value and scarcity of the mineral in all other parts of the country must make its mining in this district always extremely profitable, and its railway carriage over long distances inevitable. It must always be in demand; can always pay a high freight charge, and cannot meet with competition from the Nova Scotia plaster until it arrives within a hundred miles or so of tidewater. Westward and southward it may go five hundred miles without meeting competition.

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1871.

A DESCRIPTION

OF

PITTSBURGH AND BALTIMORE

Coal, Coke and Iron Company's Lands.

TOGETHER WITH THE

REPORT OF J. P. LESLEY, GEOLOGIST.

PHILADELPHIA:
M'CALLA & STAVELY, PRS., 237-9 DOCK STREET.
1871.

OFFICERS.

PRESIDENT,

ANDREW LYONS.

VICE PRESIDENT,

J. F. DRAVO.

TREASURER,

HON. J. M. BRUSH.

SECRETARY,

THEO. E. TACK.

DIRECTORS.

ANDREW LYONS, - - - - - -	*Pittsburgh.*
HON. JARED M. BRUSH, - - -	"
HON. R. W. MACKEY, - - - - -	"
J. H. BOYTS, - - - - - - - -	"
J. F. DRAVO, - - - - - - - -	"
JAMES BOWN, - - - - - - -	"
JNO. W. LOCKWOOD, - - - - -	*Philadelphia.*
A. H. TACK, - - - - - - - -	"
EDWARD SCULL, - - - - - -	*Somerset.*

GENERAL DESCRIPTION.

The Company's property embraces an area of 6,436 acres of mineral lands. Of this quantity the Company hold in fee simple, by indisputable title, 3,126 acres, and the coal, iron ore, fire clay, limestone and other minerals of 3,310 acres more, with all necessary mining privileges and rights of way. These latter 3,310 acres are not held as mere mineral leases, but the absolute right of property in all the minerals forever, is in the Company.

The fee simple portion consists of thirteen farms, some of them wel-improved, and in good cultivation; others with small amounts of improved land, whilst the balance is a forest, studded with large quantities of the very best oak and other hard wood timber.

The timber alone is of very great value, as the heavier portion can be manufactured into lumber, and the lighter and inferior can be used for mining purposes.

Lying close to the Pittsburgh and Connellsville Railroad, a market will be found ready for all that can be manufactured. It is confidently asserted that no better timber can be found of so easy access to market.

The farms generally have large orchards of fruit trees, and most of them fine sugar groves. Hickory, locust, ash, sugar maple, chestnut and walnut abound, but the forest is principally oak. The farms are well watered, and adapted to grain or grass.

The entire plot lies in the heart of the settlement, and not in the mountains. It is a remarkable fact that the coal beds on the property underlie the high table lands between the mountains, and are, therefore, unlike the anthracite fields, which seem to be associated with rough, barren lands.

The whole property, with trifling exceptions, can be made available as firstclass farming land. A fine bed of limestone, found on the large part of the property, furnishes a fertilizer close at hand. The water power is adequate for almost any purpose.

As one of the main features of the Company will be the coking of coal, this business will be greatly facilitated, owing to the Company possessing large and convenient grounds admirably adapted for that business.

The Company's lands extend from the town of Ursina, up North Fork River, a distance of between five and six miles. At this new town, located on the Pittsburgh and Connellsville Railroad, are aleady found good manufacturing facilities. In addition to a saw mill and foundry now in operation, a large stave manufactory is being established.

The branch railroad, which the Company may find it advisable to build for the transportation of their coal and coke, iron ore, and other minerals will also answer to transport timber and lumber found on their own lands, as well as become a carrier for lumber found higher up the stream.

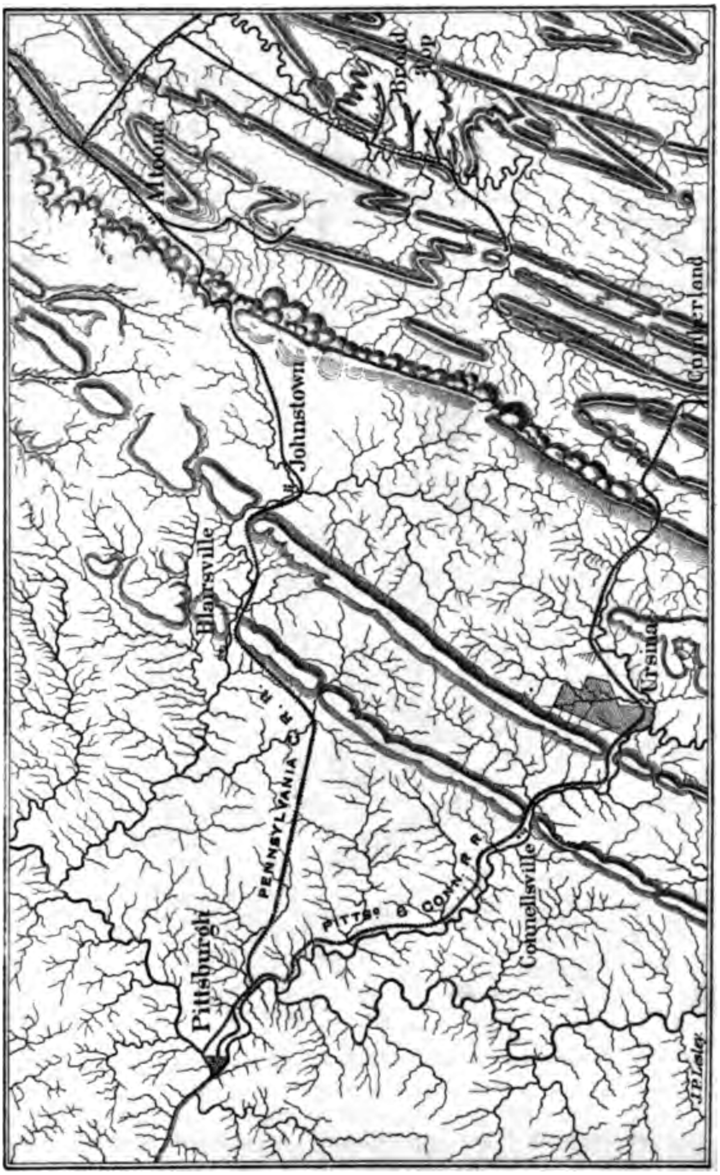
A railroad is now in rapid progress to completion from Bridgeport to Bedford, which will afford an important outlet for the Ursina Coal to the Juniata region, Philadelphia and New York.

A branch railroad is also being constructed from Mineral Point to Somerset, which undoubtedly will be prolonged to the Pennsylvania Railroad at Johnstown, giving a direct avenue for the superior fuel of the Ursina coal field to the extensive iron works of the Cambria Iron Company.

3

A MAP

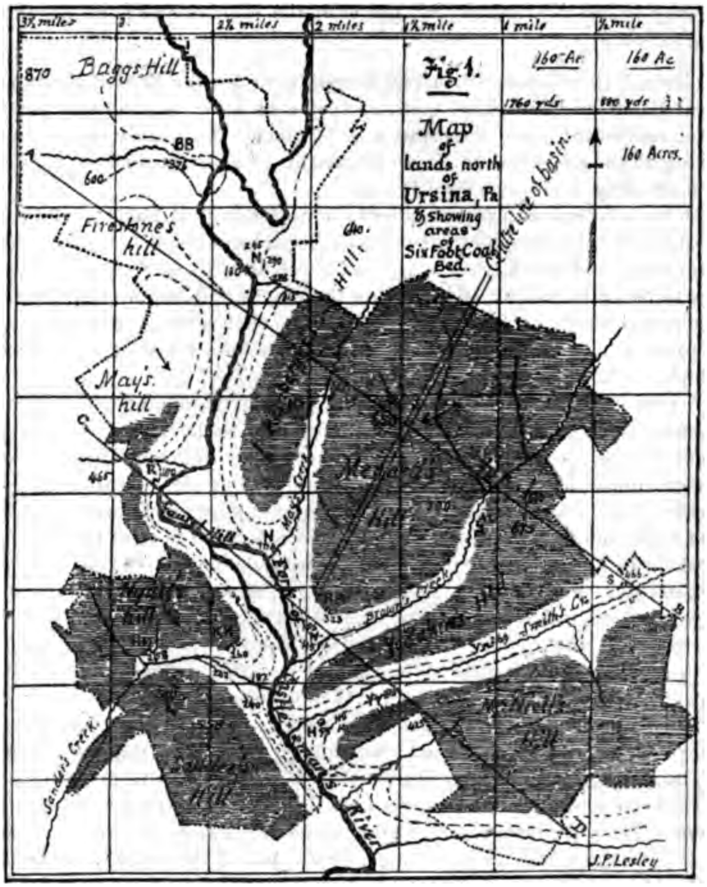
Showing the Geographical Relations of the Pittsburg and Baltimore C. C. and I. Co.'s Lands to the surrounding counties.



GEOLOGICAL REPORT
OF
6436 Acres of Coal and Iron Ore Lands, at Ursina, Somerset Co., Pa.
By J. P. LESLEY.

To the Pittsburg and Baltimore Coal, Coke and Iron Company:
Philadelphia, 1008 *Clinton Street, June* 10, 1871.

GENTLEMEN: I have had your lands surveyed, and find the following geological facts to report, premising, that I have been familiar with the neighborhood, since I first encamped on Laurel Run, now the North Fork of Youghiogheny, in 1840, in about the centre of your tract.



I have recently had your property mapped, with a view to its geology; and a reduced copy of the map will accompany this report. But I have also introduced two wood-cut sketch-maps—Fig. 1 the northern, Fig. 2, the southern part of the property—for convenience in illustrating what

I have to say about it. On these sketch maps straight lines are drawn and lettered at their ends, to mark the lines upon the land where sections were made ; which sections appear as figures 5 and 6, on page 11.

The curved lines which cover the principal map are horizontal levels above tide, twenty feet apart, vertically. They show the contour of the surface, the course and depth of the valleys, the height and shape of each hill ; and they render quite unnecessary a verbal description of the property. These contour lines will serve also for engineering purposes, and will save time and money in preliminary railway surveys. In fact, on this map, in your office, you can locate your tramways, slopes, &c.; remembering, however, that the levels were taken with a delicate and trustworthy barometer, indeed, but not with the regular and more accurate spirit-level.

General Description.—Somerset County occupies the First Bituminous Coal Basin in Pennsylvania, where that coal basin widens and passes over, southward, into Maryland and Virginia. Its extra width here is owing to the anticlinal of Negro Mountain, which runs along its central line, dividing it into two Coal Basins.

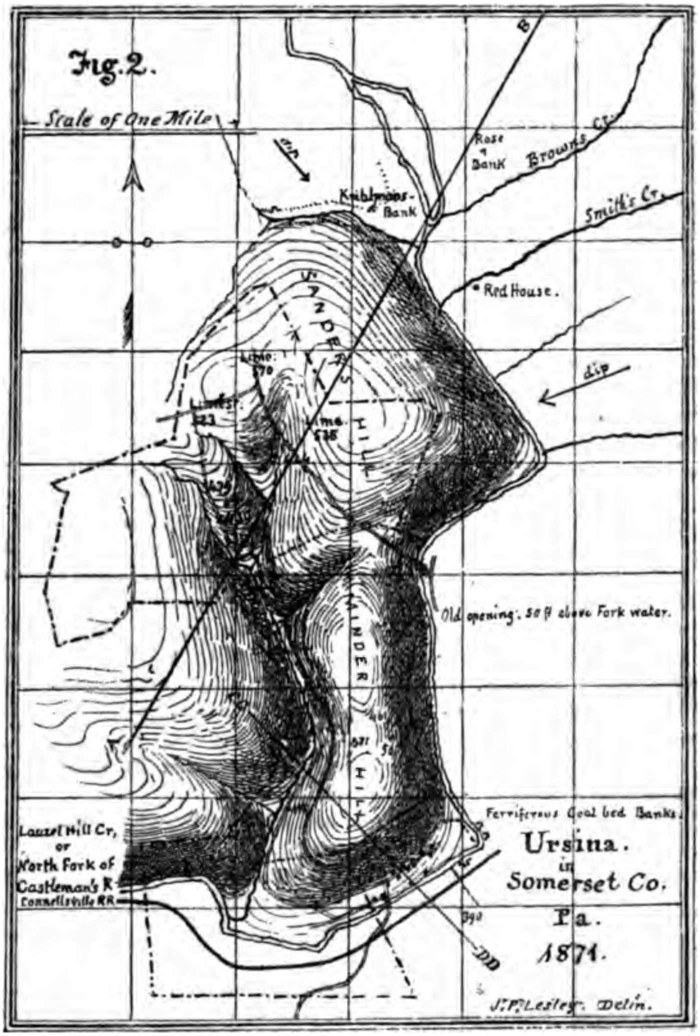
In the western of these two sub-divisions of the First Basin, and on its western side, lies your property ; occupying a pear-shaped area, five miles long north and south (that is, up and down the North Fork), and from one to two miles wide ; and covering the slopes and summits of four or five ridges which converge toward the town of Ursina, recently built on the new Connellsville Extension, or Baltimore and Pittsburgh Railroad, which has just got into running order.

A mile below Ursina, the North Fork of the Youghiogheny meets the main river coming up from Virginia, and also Castleman's river coming from the east. The three streams make the well-known Turkey Foot, famous in the aboriginal Indian history of the Colonies. United in one stream, these waters enter a transverse gap or gorge in Laurel Hill, 800 feet high, and pass into Ligonier Valley, which is the Second Bituminous Coal Basin ; and so on to join the Monongahela and the Ohio River at Pittsburgh. For the whole of this distance, from Ursina to Pittsburgh, eighty-six (86) miles, the railway runs along the river bank, through lovely scenery. In the opposite direction, the railroad ascends Castleman's River, crosses the Alleghany Mountain by a tunnel, and descends the Potomac River to Baltimore, which is 243 miles from Ursina.

The southern limit of the property overlaps the town of Ursina, the river bed, and the railway track, which is 90 feet above the water level.

The width of the property is such that it gets the *dips* from both sides of the Coal Basin, and the dead *horizontal lay* of the stratification between them. The dips, however, nowhere exceed five degrees (5°) and graduate to 0°. There is also an exceedingly gentle fall of the basin, as a whole, southwestward, towards Ursina. The hills, or ridges of horizontal coal measures, are 300 to 400 feet high. The coal beds, ore layers, and limestone strata pass through them, from valley to valley, cropping out in

A MAP SHOWING THE TOPOGRAPHICAL CHARACTER OF THE SOUTHERN PART OF THE LANDS OF THE PITTSBURG AND BALTIMORE COAL, COKE AND IRON COMPANY.



nearly horizontal lines along their sides and around their ends. Easier conditions for mining cannot be imagined. And it is in a country quite destitute of faults. The coal beds belong to the upper part of the Lower Coal System, and are as regular in thickness as in posture.

The Six Foot Coal Bed—This gives to the property its great value. In the southern part of the property it outcrops on the hill-side over the town of Ursina, at an elevation of about 200 feet above the water. Its outcrop keeps at about this height along the east flank of the Ridge (Minder's and Sander's hill) for two miles, up the west bank of the North Fork. It crops out on both sides of Minder's creek, as high up as the forks, where it gets under the water of the run, which descends rapidly.

In the northern part of the property it outcrops on both sides of the North Fork, at the same elevation of about 200 feet above water-level, for a distance of two and a half (2½) miles ;

—Along both sides of Smith's creek, for 1¾ miles :—

—Along both sides of Brown's creek, for 1¼ miles :—

—Along both sides of May's creek, for ¾ mile :—

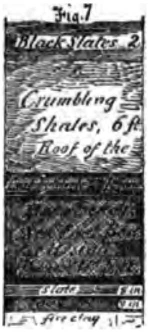
—Along both sides of Sander's creek, for ½ mile :—

So that the outcrop of this bed has a run of over ten (10) miles.

In this Northern part of the property it lies also in the best manner possible for mining ; falling gently in all directions towards a central point, or mining location, between the mouths of Smith's and Brown's creeks. The arrows on the map (fig. 4) show the direction of the fall of the coal. The two parallel lines (from R R northeastward) show the central axis of the basin, or deepest part of the coal bed, falling towards S. 30°÷W.

Down this central axis the coal bed falls at the rate of less than 1° ; or, between 60 and 70 feet in the mile. The *fall* from the Krieger bank to the Rose bank, W. S. W. is 150 feet in a little less than a mile. The rise from the Rose bank to the crop, up May's creek, northward, is 120 feet in a little over a mile.

Fig. 7



The following openings on this Six Foot Bed have been worked for several years :—

The Krieger Bank, one mile up Brown's creek, south side ; 9 feet above the water-bed ; runs in 109 yards, E. 10° S. ; coal mined from several small breasts, not many tons altogether. It is represented in Fig. 7.

Top Rocks : Black Slate	2 feet.
Crumbly Shale	6 feet.
Top coal, with three half inch slates	1 foot.
Main coal, solid bench, with occasional wedges of drab clay	5 feet.
Slate not taken up	8 inches.
Bottom coal, bench not taken up	9 inches.

The following analysis by Mr. Persifor Frazer, Jun., shows a superior

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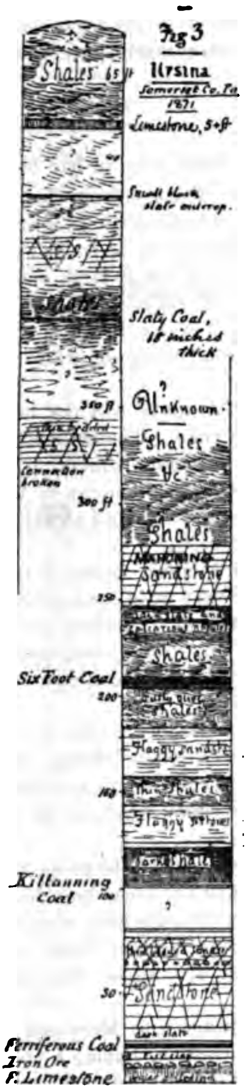
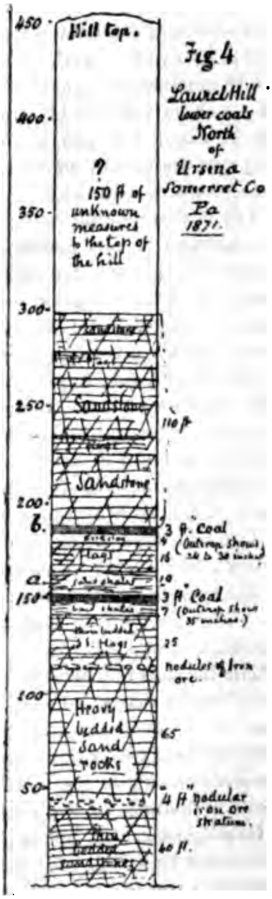
VERTICAL SECTIONS OF THE COAL MEASURES NEAR URSINA, SOMERSET COUNTY, PENNSYLVANIA, BY FRANKLIN PLATT, JR.





percentage of solid carbon with a minimum of ash, sulphur and water :—

Carbon (coke)	79.25	(or ⅘ of the whole.)
Volatile substances	17.17	(It is therefore not a gas coal.)
Ash	3.11	(an extraordinarily pure coal.)
Sulphur	0.47	
Water	0.55	

Total......................100.55 : in which the sulphur has been considered exclusively a constitutent of the Ash. The specimen (No. 1) was obtained from the Krieger bank, some distance back in the gangway, and midway of the bed, between the roof and floor, and may be considered a fair specimen of what the bed will do when mined on a large scale. The ash is remarkably small—the coke very great (nearly ⅘ths of the whole); and the gas no higher than in Broad Top Coal; water and sulphur about half of one per cent. The small percentage of water in these coals is remarkable.

The coal is friable and comes out much crumbled, and will not bear transportation, but makes a very nice grey even coke. The crumbling shale roof will call for very careful mining and abundant timbering to keep the mine in good order. But while timber is abundant in the district, longwall mining will let the roof fall behind and afford plenty of slate stuff for gobbing up, where needful.

The Rose Bank, opposite the mouth of Brown's creek, facing south, 220 feet above water; shows six feet face of coal, very good, except that there are a few thin layers of slate in the top bench of 12 inches, as before; a coal of 8 inches is said to underlie the bed, as before; roof, again, crumbly shale; coal very friable; it is roughly coked in the open air in front of the mine and makes good coke.

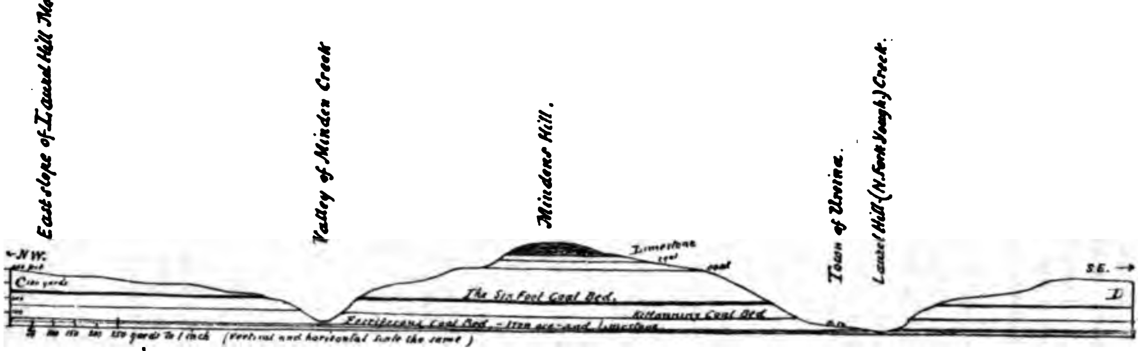
The Kuhlman Bank is opposite to the Rose, on the west side of the valley; and an old mine is ⅔ mile further west on the same outcrop, and at the same level, 25 feet above the bed of Sander's run. Both are fallen in. The people say that the bed exhibited the same character as on Brown's creek.

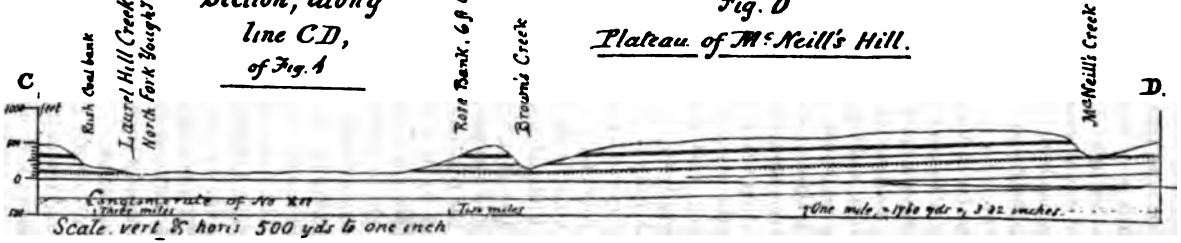
The bed has not been fully opened at the southern end of the property, but I see no reason why it should differ in quality or thickness here from where it is opened further up the North Fork, since it runs with remarkable regularity of thickness and character from the Krieger bank (up Brown's creek), to the Kuhlman bank and the old opening on Sander's creek, a distance of two miles.

Geologically, this bed is the continuation southward into Maryland of one of the two beds of the Alleghany River Coal System, having a wide extension through western Pennsylvania, and always furnishing the best of coal. For want of special instrumental surveys in the country south of the Conemaugh, it is not now possible to assert positively to which of these two Alleghany River Coal beds, the Six-foot coal in southern

HORIZONTAL SECTIONS OF THE COAL MEASURES NEAR URSINA, SOMERSET COUNTY, PA., BY FRANKLIN PLATT, JR.

Fig. 5. Section CCDD, though the town of Ursina, Somerset Co. Pa. 1871


East slope of Laurel Hill Mountain.
Valley of Minden Creek
Mindens Hill.
Town of Ursina.
Laurel Hill (N. Fork Yough.) Creek.
← N.W.
S.E. →
D
Limestone
coal
coal
The Six Foot Coal Bed.
Kittanning Coal Bed
Ferriferous Coal Bed, – Iron ore – and Limestone.
250 yards to 1 inch (Vertical and horizontal Scale the same)



Section, along line CD, of Fig. 4

Fig. 6

Plateau of Mc Neill's Hill.

Scale. vert & hori: 500 yds to one inch

Somerset county, answers best. Our best guide, the great lime rock which underlies the upper of these beds, thins out as it approaches the Allegheny Mountain and the Maryland line. But as we have a dark Shale with limestone nodules, overlying our Six-foot coal bed, and beneath what is probably the Mahoning Sandrock, in the same position as that occupied by the upper of the two Allegheny River beds, the Six-foot coal would seem to be the lower. The question is, however, unimportant, because both the beds in question are remarkably good, and run more regularly than the beds of the Kittanning and Clarion groups underneath them.

So far as this bed is concerned, the business of the Company will be to manufacture coke for the Pittsburgh market, in competition with the coke collieries at and below Connellsville; and at a not far distant future time for markets on the seaboard.

If a colliery were established at the mouth of Brown's creek, three incline planes could be laid up the ends of Younkin's hill, Menard's hill, and Hyatt's hill, and from the tops of these three planes, three main entries would have three unbroken coal fields straight before them, with a rising coal; in Youngkin's hill rising eastward; in Menard's hill rising northeastward, north northeastward and northward; and in Hyatt's hill rising west northwestward. The point is a rare one for large mining operations.

A railway branch three miles long from this point will place the coal on the cars of the Baltimore and Pittsburgh Railway, at Ursina. Plenty of room exists for coking furnaces; and the coke would reach Pittsburgh in eighty-nine (89) miles, (six miles less than the distance from Pottsville to Philadelphia).

The gangway entering Menard's hill (at or near the present Rose bank), would command an unbroken area of one and three quarter square miles of the Six-foot bed, containing the *gross* amount of......10,500,000 tons,
and by tresseling May's and Brown's creeks at their
upper parts where the bed is near their water level, mining
might be carried forward into the Ramsberger and Krieger
area, and add.. 1,500,000 tons,
making in all..12,000,000 tons,
commanded by this gangway.

The gangway at the end of Hyatt's hill, would command 2,250,000 tons,

The gangway at the end of Youngkin's hill would command.. 1,500,000 tons.

The amount of coal to be reached in the easiest possible way, and concentrated at one coal dépot at the mouth of Brown's creek, is therefore evidently larger than the necessities of the largest collieries for an entire generation.

When the main gangways become inconveniently long their air-ways along the outcrop will afford the most convenient outlets for slack and waste; and new gangways can enter any where because the drainage of the mine will be perfect.

There is fine coking ground at the mouth of Minder's Creek, and I think that careful leveling of the outcrop around the south end of the hill, with a few auger-holes to get the level a little back from the outcrop inside the hill, will show that the best, place for establishing the mouth of the colliery is on the slope back of the town. The rise of the coal through the hill is gentle, towards the east. The line A B is the *theoretical* entre line of the basin; and is the *real* centre line of the basin on the P. & B. C. C., & I. Co.'s lands. Whether this line is the *real* centre line through this property or not, can only be made out by very careful leveling. There may be an exceedingly shallow and almost flat basin through Minden's Hill, as I have drawn it in the section given in fig. 5. It will not be advisable to open the bed anywhere along the east flank of the ridge, for a long time to come; that is, until the gangway from the south has got its airways driven through *up dip* in that direction; after which these airways may be converted into gangways, and coking grounds be estabished on the Laurel Hill Fork, a half a mile, a mile, or a mile and a half above Ursina, with tramways down the fork to Ursina. The fork water falls about 40 feet to the mile, and a tramway bed can be cheaply made by side-cutting in the hill side.

A fine colliery can also be established at the forks of Minder's Creek, a mile and a half above its junction with the North fork. Here the Six Foot bed strikes the water level of the run for gangways to be driven in horizontally west, northwest, north, northeast, and east, commanding an entire square mile of the property, or six million tons of coal. The tramroad for such a colliery will be, say 1¼ miles long, with a grade of 1°, or between 90 and 100 feet to the mile, which may be lessened by judicious arrangements.* This point has another advantage: it will permit *all* the Sander's Hill coal to come out, down grade. I never saw a more beautiful situation for a first class colliery on bituminous coal. Nor do Iknow of a better coal on which to establish a great coke trade.

Five hundred acres of timber land remain on this hill to furnish props; an abundance of which, however, can be got from the mountain.

The Turkey-foot is sure to become a second Johnstown, also, in the way of iron works, occupying precisely the same position, geographical and geological, upon the Baltimore and Pittsburgh through railway line, which Johnstown occupies on the Philadelphia and Pittsburg through railway line; as the map on page 3 will show; and just as Blairsville and Connellsville, occupy precisely analogous situations, geological and geographical, to each other. At Ursina, the coal beds, iron ores, limestones occur in the hills in the same way that they do at Johnstown; the hills are of the same shape; and the minerals lie at the same angles with the horizon, and at similar heights above water level. At both places the Pittsburgh and Green county coal beds are absent, swept from the tops of the highest hills. At both places the blue carbonate iron ore of No. XI. underlies the conglomerate on the flank of the mountain near the top. And as Johnstown gets brown hematite ores from the limestone valleys of the Juniata, and fossil ore from Frankstown, and Lake Superior ore from Cleveland, to mix with the ores under the coal beds in its hills, so Ursina can get fossil ore and brown hematite from Cumberland and other points on the Potomac, and the same Lake Superior ores via Pittsburgh, to mix with same iron ores which lie in the hills sides of Castleman's river and Laurel Hill Creek.

Two other coal beds range through the property. The Kittanning bed 100 feet lower down the hillsides than the six foot; and the Ferriferous bed, nearly at water level. Two small seams of coal exist, also, in the hill tops.

The Kittanning Bed averages 2½ feet, which is best opened at Ursina. This bed outcrops all around the hill sides, north of Ursina, but goes beneath water level of Minder's Creek, two-thirds of a mile up from its mouth. It outcrops all the way up the North fork.

A thirty inch coal bed is opened at the Rush Bank, 1½ miles above the mouth of Brown's Creek, (fig. 1), 25 feet above the water of the North fork (Laurel Hill Creek). This bed underlies the Six Foot about 100 feet, and is the Kittanning coal bed. It shows 30 inches of good hard coal, with 15 inches over it of slate mixed with thin coal seams, and a roof of soft shales, requiring careful timbering. Its floor is a massive sandrock, without a particle of intervening fireclay. The bed has only been stripped at its outcrop ; but yields cubical masses of very firm coal.

The Ferriferous Bed, (so called, not because it carries, itself, any iron, but because it always comes into the measures just above a limestone which is called ferriferous, because it carries on its upper surface the great iron ore deposits of north west Pennsylvania, especially in Clarion, Venango and Armstrong Counties), averages 2½ feet, and lies just above water level at Ursina. It sinks beneath water level going west, down the fork. It has been opened also on the property at the mouth of May's Creek, and at the mouth of Brown's Creek, on both banks of the creek. On the north bank 25 inches of coal is visible, with a 3 inch slate parting. On the south bank 20 inches of coal, 3 inches slate, 5 inches of coal; roof, 2 feet of iron-stained shales supporting 30 or 40 feet of sandstone; floor, hard slate ; under this, a thick bed of fire-clay, containing nodules of iron ore; under this, limestone, said to be 18 inches thick.

The bed is not thick, but its quality of coal is good; the mineral coming out in solid blocks, and apparently adapted for the iron manufacture. Mr. Frazer has made two analyses of it, with the following results :

	No. 1.	No. 2.	Mean.
Volatile matters and water......	17.12	17.13	17.125
Water alone....................	0.30		
Fixed carbon..................	68.20	68.87	68.535
Ashes.........................	14.68	14.00	14.34

Another specimen taken from the Widow Croll's bank, near the mouth of Brown's Creek, shows the same character of this lower coal, over the limestone; equally free from water and sulphur as the Six Foot bed; more gas (equal to Alleghany Mountain Coal in this particular); a large quantity of ash; and 3-5ths of it coke.

Water	0.55
Volatile substances (Gas)	21.90
Carbon (Coke)	60.98
Sulphur (in ash)	0.62
Ash	15.95

These analyses are very satisfactory.

The Ferriferous coal is also opened at the head of Smith's Creek, on both banks of the creek. On the south side a pile of half burned lime, shows how strongly ferruginous the limestone stratum is. On the north side, the outcrop exposed by digging, shows two feet of coal, the upper foot slaty; 1 foot of clay, with nodules of ore, in the roof; over this again 1 foot of sandstone; then one foot of dark slate; then a heavy sandstone. The floor is a thick bed of fireclay, the upper 3 or 4 feet being closely filled with nodules of iron ore.

This bed underlies nearly the whole property about water level, and is very consistent with the character given above. At Ursina it shows the same slate parting near the bottom, and the same underlying beds of fire clay, iron ore and limestone. It will probably play an important part in the future development of the Turkey foot district.

At the base of the Ramsberger Hill and on Bogg's Creek, at the north end of the property, this coal, and another bed 30 feet betow it, (see section fig. 4), apparently 24 to 36 inches thick each, and mixed with slate, occur again, and no lower measures are visible anywhere. The conglomerate at the base of the coal measures is just underneath them; the same which may be seen in the gap below Confluence, making a great arch in the mountain.

The ferriferous limestone shows about 18 inches thick on the east bank of the North fork, but its general thickness I do not know. It is the same deposit which on the Slippery-rock and Beaver River country furnishes the *soda*-lime for the Pittsburgh works. On Smith's creek the farmers have tried to burn this limestone for use, but failed, and the calcined fragments show how much iron it must contain; it may, therefore, make a superior blast furnace flux.

Diligent search should be made all along the outcrop between the limestone and coal, to find places where the ore deposit may be abundant enough to work. A small (2 inch) layer of nodules of iron ore occurs about 65 feet above water level at Ursina, but it is, of course, worthless at this point.

The fire clay under the ferriferous coal is usually about 4 feet thick.

A small coal bed outcrops 127 feet above the Six Foot bed, over the Krieger bank. (Elk Lick coal?)

One of the lime stones of the upper part of the barren measures, comes in between 475 and 525 feet above water level, near the summit of Minder's Hill, and extends through the hill tops of the property west of the North fork. It is at least 5 feet thick, ferruginous, and will be useful.

About 100 feet below this lime stone is a thin coal vein, very slaty, and good for nothing. There is also a bed of coal-slate 40 feet under this upper limestone.

The Iron Ore of the Red Shale No. XI, under the conglomerate of the mountain can be opened in the gap, and also along the mountain side near the top, at the northwest corner of the property; it is usually a plate of blue carbonate of iron, from two to four feet thick, and very regular.

Estimate of Coal on the Property.—The Six Foot bed, which underlies about 4200 acres of land, contains about Forty million (40,000,000) tons of coal.

The Kittanning Coal Bed, the outcrop of which is marked on Map, fig. 1, by the dotted line nearest to the dark areas, underlies about 5000 acres, and contains from eighteen to twenty million tons of coal.

The Ferriferous Coal Bed underlies about 5000 acres, and contains from twenty to twenty-five million tons of coal.

The total *gross* amount of coal held in the three beds above mentioned, may be stated as between Eighty and *Eighty-five million tons*, or, after all deductions made for loss in mining, and on a basis of 1000 tons per foot per acre, fifty millions (50,000,000) of tons.

Respectfully submitted,

J. P. LESLEY.

REPORTS

ON THE

P. KERR & CO. COAL LANDS,

IN WASHINGTON COUNTY, PA.

BY

J. P. LESLEY, Philadelphia,

AND

W. H. BOAL, Pittsburg.

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SHERMAN & CO., PRINTERS, PHILAD.

REPORT

On the P. Kerr & Co. Coal Lands, Washington Co., Pennsylvania. By J. PETER LESLEY, *Topographical Geologist.* (1016 *Clinton Street, Philadelphia, December,* 1864.)

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1. SITUATION.—At the lower end of Lock No. 4, or at the southern end of the third dam of the Monongahela river, 39 miles above Pittsburg, and on the western bank, in Fallowfield and Carroll townships; as the accompanying map A will show.

The distance by river down to Webster is 4 miles; to Monongahela City, 9 miles (by road, 3½ miles); to Limetown, 12½ (by air line, 6½ miles). The distance by river, up to Bellvernon, is 3½; to Cookstown, 5½; to Greenfield, 10 (by air line, 6); to Brownsville, head of steamboat navigation, 15 miles.

In map B the blue lines comprehend the mineral rights of the property, and the red lines the 28 acres held in fee simple, along the river front, and up the little runs. A represents the opening at the end of a proposed railroad, in the outcrop of the Pittsburg coal bed, 117 feet above the river water-level.

There are 1003 acres, in all; about 15 (fifteen) acres are destitute of coal; the 28 acres held in fee simple include the space between the river front (1137 feet long) and the cliffs over the outcrop of the bed; in other words, the cliffs over the river and the first terrace, F, about 100 feet high, on which the railroad will run. Timber for mining, and room for erecting buildings are thus furnished. The mineral rights consist of all the *coal* under the whole 1003 acres; and of all the *limestone and other minerals* under the front division, embracing 420 acres. This extent of coal-rights might be indefinitely enlarged by the purchase of properties lying to the west and south, at present held cheaply because shut out from the river front unless mined through this property, but at no greater distance from the river through this property than many coal lands are which lie back from the river, along Pool No. 1, and yet are held at $1000 per acre. Some of the little railroads leading from the river, back to coal properties so situated, are two, three, and four miles long, as shown on Map A. While the value of lands on Pool No. 1 and Pool No. 2 has got to be well understood, their value on Pool No. 3 has not attracted much attention until lately, since the great advance in the price of coal. Now, quite a number of collieries have been successfully established on this pool, and others are under way, but not completed. Coal delivered in flat-boats and barges in this pool brings nine (9) cents a bushel ($2.50 per ton); and, as the maximum cost of mining could not exceed 5 cents ($1.40), the profit is at least 4c. ($1.10). Slackwater navigation secures access to the landing at all times, and Ohio craft lie in the pools, loading with coal, to be ready for a move, the moment there is a boating height of water in the Ohio, to the western markets, in which the Monongahela coal (Pittsburg coal

as it is called) is well understood to be the best that can be got. The Wheeling, Pomeroy, and other coals from the western side of the great coal field, have a larger percentage of sulphur in them; and the percentage of sulphur increases continually (for some unknown reason) towards the west; so that the Monongahela coal has always commanded, at St. Louis, just double the price of St. Clair (Illinois) and St. Louis (Missouri) coals;* and it has been, in fact, the only coal which the St. Louis *Iron Works* could afford to coke for their own use. The Monongahela coal-lands will, therefore, always, and for strictly geological reasons, possess a superior value.

The progress of mining up the Monongahela is the evidence and the consequence of this state of things. It has a natural and regular growth. As the mines of the First Pool were driven in to greater and greater distances from the river front, those of the Second Pool came into use; and now that the frontage of the Second Pool has been taken up and is getting worked deeply into, the favorable bluffs of the Third Pool are being opened. As the charges on the river are not per mile, but per lock and per pool, all points *on any one pool* are equally favorable to the miner, so far as cost of transportation is concerned. The situation of this Kerr tract has, however, a slight advantage in being just below a lock (No. 4) which is a favorite hauling-up place for river craft.

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* Monongahela coal brings from two to three cents more than other coals, in the Cincinnati, Louisville, Memphis, Vicksburg, and New Orleans markets.

2. Cost of Transportation.—The present *river-charges* are as follows:

For Lock No. 1, ...	$1 00	per 1000 bushels.
For Lock No. 2, ...	96	per 1000 bushels.
For Lock No. 3, ...	75	per 1000 bushels.
Whole cost of Lockage, . .	$2 71	per 1000 bushels; or

at the rate of about 7½ cents per ton of 28 bushels.

The towage, which was formerly $25 to $30, is now $50 per 12,000 bushels, in barges, delivered at Pittsburg (for the round trip), and charges in addition on a sliding scale, by which it costs, from Pool No. 1, $3.00 per 1000 bushels of coal; against, from Pool No. 3, $7.11 per 1000 bushels of coal; or at the rate of 21 cents per ton of 28 bushels.

Against this discrimination (of $4.11 per 1000 bushels) in favor of the First Pool coals against the Third Pool coals, produced by lockage and towage, there is an offset in the shape of 1. Cheaper land. 2. A larger bed. 3. Virgin collieries close to the bluff.

To work most effectually, a Company should have its own means of transportation. By owning a couple of tug-boats, which should descend the Ohio river with the Company's barges when necessary, delays and losses would be avoided. This plan has been adopted and found to work well at certain collieries.

Two daily packets ply between Pittsburg and Brownsville, and stop at Lock No. 4, close by the face of the property. A ride of three miles to Monongahela City affords also telegraphic facilities, to an office at the wharf.

The Mineral Contents of the Property.—*Coal* and *limestone* are the principal; *fire clay* and *building stone* are subordinate, and need no special mention, as they occur below and above all beds of coal; *iron ores* of the coal measures, are not abundant in this part of the region, and only one bed is deserving of attention; finally, *petroleum* can only be obtained by boring deep, since the first oil-bearing rocks known to us lie about eight hundred feet beneath the Pittsburg coal bed. The horizontal position of the other formations beneath them and over them, up to the top of the highest land on the property, will be seen, with a sufficient approximation to the truth, by the vertical Section, C.

The Middle Coal Measures are sunk so deep beneath the Monongahela, that it will be many years before any attempt will be made to mine their beds, the top one being about 300, and the bottom one about 700 feet beneath the river bottom. But they form an immense reserve of fuel for times to come, when the Pittsburg-bed shall have become worked out, for miles back from the river. One or two of these Middle-Measure-beds are probably very nearly if not quite as thick and good as the Pittsburg-bed itself. *The lower coal measures*, on the contrary, are probably worthless under all this region of the Monongahela valley. *The lower petroleum measures* we know nothing or very little about, for they lie below the deepest holes of the old salt works of the region. But the immense range which they have, from Western New York, through Ohio, Kentucky and Tennessee, and the fact that they are oil-bearing along the whole range, justifies us in supposing that they are oil-bearing under the Pittsburg country, at the depth at which we know they lie. This gives us an explanation of the fact that some of the deep salt wells of the Monongahela and Alleghany branch valleys were greatly troubled by quantities of gas and petroleum. To this must be added the fact of recent successful borings for petroleum about thirty miles higher up the Monongahela; the fluid in this instance coming, not from the Devonian Petroleum Measures, but from the uppermost petroleum-bearing stratum, in the conglomerate or just below it, as in Beaver County, Pa. I see no reason to doubt the probability of getting petroleum by borings of 700 feet in depth at Lock No. 4.

Three coal beds lie horizontally, through the hills of this property, above water-level, to which several others might be enumerated in addition, smaller and quite worthless—all of them above the principal bed of the region, the Pittsburg-bed, which gives its chief value to the property. (See Fig. 534, &c.) Thus:—

THREE HUNDRED FEET ABOVE THE PITTSBURG BED, and at the extreme tops of the hills, lies the 4½ or 5 feet bed of Waynesburg, yielding a good coal, but of very little if any value north of the Brownsville country, on account of its high position, and its rather variable size.

TWO HUNDRED FEET ABOVE THE PITTSBURG BED comes in the Uniontown coal, which is 3½ feet thick at Brownsville, and may be found low enough in the hill-tops of this property, and thick enough, to work.

ONE HUNDRED FEET ABOVE THE PITTSBURG BED ought to come in the Sewickly bed, which is 5 feet thick in the Uniontown region, and a workable bed on Sewickly creek, but is probably quite thin and concealed among the layers of the Great Limestone Formation at Lock No. 4. A thorough search ought to be made for this bed on the property.

THIRTY OR FORTY FEET ABOVE THE PITTSBURG BED lies the little Redstone Bed, never more than 2 feet thick, and quite worthless, as may be seen from the sections on page 7.

The Pittsburg Bed itself is that which gives its chief value to the Valley of the Monongahela, and to all the country south of the Kishkaminitas, Alleghany and Ohio rivers. It is a wonderful layer of coal, which originally spread itself out, in an unbroken sheet, from Eastern Pennsylvania to Western Kentucky, and southwards into Tennessee. It is thinner along its northwestern outcrop around Pittsburg, and thicker toward the Maryland line. It is everywhere divisible in two parts: an *upper*, *bony*, *slaty stratum*, commonly left in to form the roof, and varying from three to five feet in thickness, often including one or two thin layers of good coal, and often very sulphury; and a *lower stratum of good coal*, which is mined, but of which, sometimes, the lowest part, next the floor, contains also too much sulphuret of iron to take out. In the neighborhood of Pittsburg, about six inches of this is left on the floor, and 4 or 4½ feet of clean coal mined. In the neighborhood of Brownsville, there is a roof of 17 inches slate, then 2 feet coal, then a little slate, then the main body of coal 7 (seven) feet thick. It is quite a geological certainty that the Bed will yield six (6) feet of good coal in all the gangways of the property at Lock No. 4.

The quality of the coal I have already alluded to above; it is the best bituminous coal known in the United States (except the Peytona cannel, and a small bed, in a region further north), and can be employed in manufacturing gas, or coked for manufacturing iron; it is principally used for raising steam in factories and on boats, and for domestic use throughout the Valley of the Ohio and Mississippi rivers, in all the principal cities and towns upon their banks, where it commands an extra price over inferior coals, mined further west. From this Pittsburg bed, where it outcrops along the Pennsylvania Railroad, at Irwin, Penn and other stations upon Turtle Creek, the gas-coal used at the Gas Works of Philadelphia and New York city, is obtained. The quality of the coal for turning into coke, for use in iron-works, diminishes as it approaches the Pittsburg neighborhood, and improves as it recedes up the Youghiogheny and Monongahela Valleys; so that the coal coked for the Pittsburg mills is brought down from the West-Newton & Connellsville mines. The first cause of this difference is of course the presence of sulphur. But why the deposit of sulphur (in the form of pyrites) should have been greater near Pittsburg than near Brownsville or West Newton, it would be hard to explain. It is probably owing to a difference in the character of the overlying rocks, the long drainage from which down into the coal has no doubt been the principal means of introducing the pyrites. It is possible that the presence and size of the Great Limestone may have much to do with it. Whatever be the cause, the fact is important, and adds value to the bed as we ascend the Monongahela Valley. Thus in Pool 3, both the purity and the solid contents of the bed are an improvement upon the Pittsburg neighborhood or Pool 1.

THE QUANTITY OF COAL is easily estimated. A thousand acres of a horizontal good six-foot bed contain nine and a quarter million tons of coal, of which six or seven millions can be mined out and sent to market, after making the largest possible deductions for faulty streaks in the bed, mistakes in underground surveys, and waste in handling.

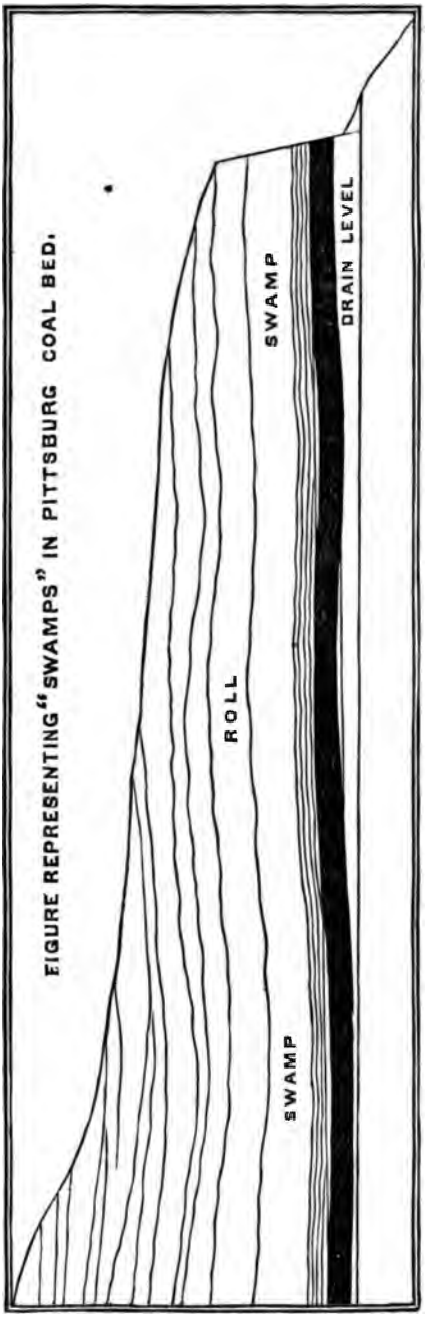
THE MINING FACILITIES OF THE PROPERTY are entirely satisfactory. The bed outcrops over a terrace, and about 120 feet above river level; the terrace itself, at its outer edge, where the top of an inclined plane would be placed, is 105 feet above water-level.

The dip of the rocks is toward the northwest, toward the centre of the Great Pittsburg or Washington County Basin. But this dip is so exceedingly gentle, that the fall of the coal in that direction is only about one-third of one degree (⅓°), or about 30 feet to the mile; for the coal bed, which is 120 feet above the Pool surface at Lock No. 4, is only 30 feet above it at Monongahela City. The little run at the north line of the front part of the property cuts deeply down through the measures, exposing the coal on each side of the ravine, for one or two thousand feet back from the river face, as shown on Map B, on which the dotted line represents the inclined plane and a little railroad track intended to start from the head of it and to run along the narrow terrace, under the outcrop of the coal, 585 yards, up the south bank of the ravine, to a point, A, where an entry into the coal can be made at the furthest possible distance back from the river. The double dotted line, Aa, represents the course which the main entry will pursue, on a dead level, so as to drain itself and all that body of coal which lies to the southeast of it, amounting to some twenty-two hundred thousand tons of coal (2,200,000). Mr. Boal, an experienced mining engineer of Western Pennsylvania, proposes a double entry at this point, A, separated by a continuous pillar, seven yards thick, for in- and out-cars, and ventilation. He proposes a shaft at B, 95 feet deep, to the bed, and a second parallel gangway from that point, which will command the next division of the bed, containing say sixteen hundred thousand (1,600,000) tons. By driving the adit A B straight on to C (or curving it to the right, so as to go square down the dip) 400 yards further, he proposes to use a syphon between C and B, and then to pump from B to A, placing the pumping engine at the top of the shaft. A third main gangway, Cc, would thus be got to command another 1,500,000 tons, &c. At D, a shaft 60 (sixty) feet deep, sunk in the bed of the ravine (a branch of Taylor's run) would also strike the coal—at least such is the calculation from levels made by Mr. Boal, and I have no doubt they are correct.

The foregoing plan of mining is a good one, although a little old-fashioned. I should prefer to enter this beautiful coal bed on its face, with large permanent entries, run due west, say along the lines Gg and Hh, with cross entries, coming out at A, and at some other point on the other run at the south line of the property, and also at B, where a shaft might and should be sunk to meet it, and other short shafts at other low points, for additional ventilation and for convenient man-ways. For drainage I should prefer to trust, at first, to deep ditching between the rails, carefully covered and kept diligently cleaned out. A drain four feet deep at the mouth of the main entry would, on a dead level, come to the grade of the railroad about 235 yards in, ***supposing the floor of the coal bed to be perfectly even in its dip*** of 30 feet to the mile. A deeper ditch would, of course, drain still further back. But for the permanent drainage of the mine, for the first few years, at least, I should employ hot-air-engines, such as the improvements on the Ericsson engine which the Roper engine and the Shaw engine (both of Boston) afford. I introduced this system into the indipping mines of the Broad Top, and it has been entirely successful. These little engines are perfectly portable, and will work in a little chamber sunk in the pillar of the entry, and can be shifted from one such chamber to another, as the heading advances. On so extremely gentle a dip as will be encountered here, it is not worth while to erect a permanent engine house at the top of a shaft, to pump an amount of water which will probably be very small, and which a small air-engine can send back to the mine's mouth. But the special advantage of using the air-engine here is this: The floor of the Pittsburg bed is *not* a perfectly even plane. It is subject to slight rolls or waves,—very slight, it is true, but yet serious annoyances to the miner who plans a system of natural drainage for an extensive colliery. Either the roof or the floor has to be shaved, to keep the track and drain level, and this makes the turning into the rooms awkward. The air-engine is ready to meet every such emergency; and can be so placed inside the mine as to keep the low places between the rolls dry, and permit the gangway to keep entirely between the floor and the roof of the bed. The height of these "rolls and swamps" varies from one to five feet, and I have known them to go up to ten feet, the variation extending over a width of from a hundred feet to a hundred yards. See the following Fig. p. 12.

But a still better way would be to use the stationary engine power at the head of the inclined-plane to drive air into the gangway, through a tube, armed near the heading with a flexible hose, and to use the air so driven in, partly for ventilation, and partly to pump or to expel the water by direct action, as in a Geffard Injector, or as in a water blast of a Catalan forge. By such an arrangement the miner is left at liberty to drive his gangways and cross headings to suit himself, and to suit the "butt and face" of the coal in the mine.

It is almost superfluous to make these suggestions, the working of the bed will be so easy by any method. But I can see no good reason for beginning the mine 600 yards

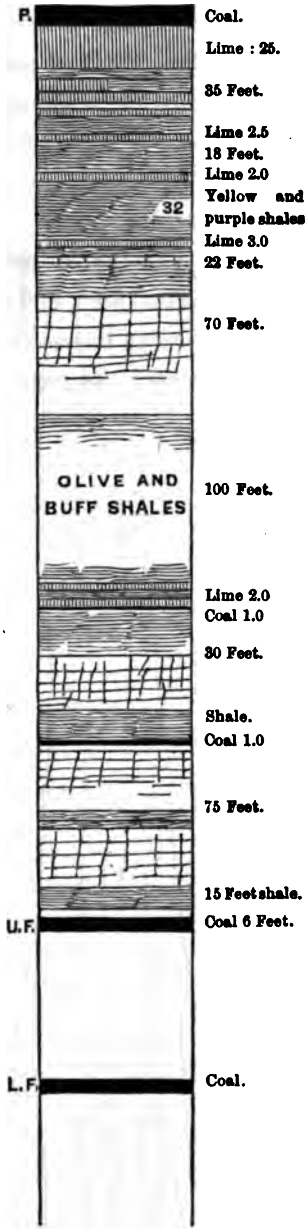


away from the shute, or for dragging the coal from the front outcrop backwards into the hill, then sideways to A, and then 600 yards eastward and southward to the shutes, thus describing a useless circle of a mile, when it could be shot out almost from the place where it lies. When the mine is well developed, say in two or three years from now, it may be well to have additional gangway mouths, one of which will, of course, be at or near A. By carrying up the incline to a level with the outcrop of the bed, 10 or 15 feet above the terrace, the expense of a railroad will be avoided; and the railroad can be made at some future time to run coal from A. The miners' houses can be built on the terrace in such a way as to allow of a future railroad track being laid down; and a siding for cars might be made at once, although this can as well be done in a fan-shaped set of short gangways on each side of the principal entrance.

One hundred bushels of coal from this bed will yield about one hundred and thirty bushels of fine coke, selling now for ten cents (10 c.) per bushel at the ovens in Pittsburg. On the Youghiogheny river, the shale in the roof of the bed has been found to make a capital fire-clay, sold just at present in Pittsburg at $2.50 per ton. About thirty feet under the bed, in many places, to the eastward, is found a valuable bed of iron ore, which may prove valuable here also.

When the main gangways have been driven in far enough to allow of a hundred rooms being turned off from them on

Pittsburg Bed.



each side (allowing 3 yards to a pier and 8 yards' width to a room), there can be taken out of each gangway between two and three hundred tons per day.

I will only add a section of the rocks below the coal bed to show what a *shaft* sunk at water-level (or say, 100 feet below the main bed), will reach, in the shape of other coal beds, for future mining. At a depth of say three hundred and seventy-five (375) feet it would pass through the large Upper Freeport Bed, and say a hundred feet deeper through the large Lower Freeport Bed. Other less important beds lie lower still. See page 13.

J. PETER LESLEY.

Report connected with Coal-Field situate a little below Lock No. 4, on the Monongahela River, in Washington County, the property of P. Kerr, Esq., & Co.

The approach by railroad, from opening at A in Rice's Run and bed of coal to the head of incline, is about 585 yards, giving a miner's grade of about 1 in 100, the incline being 54 yards in length, with grade of about 5 in 12, or an angle of 24° 35′, with level space at shipping point of 60 to 70 feet, which point is 38 feet above ordinary water-line, at which stage, as to depth of water, coal may be shipped without the least inconvenience or delay, and boats dropped down into a safe harbor, below shipping platform, for the distance of 300 feet; and by the construction of an ice or breakwater a little above the shipping platform, this harbor would be much extended out from shore.

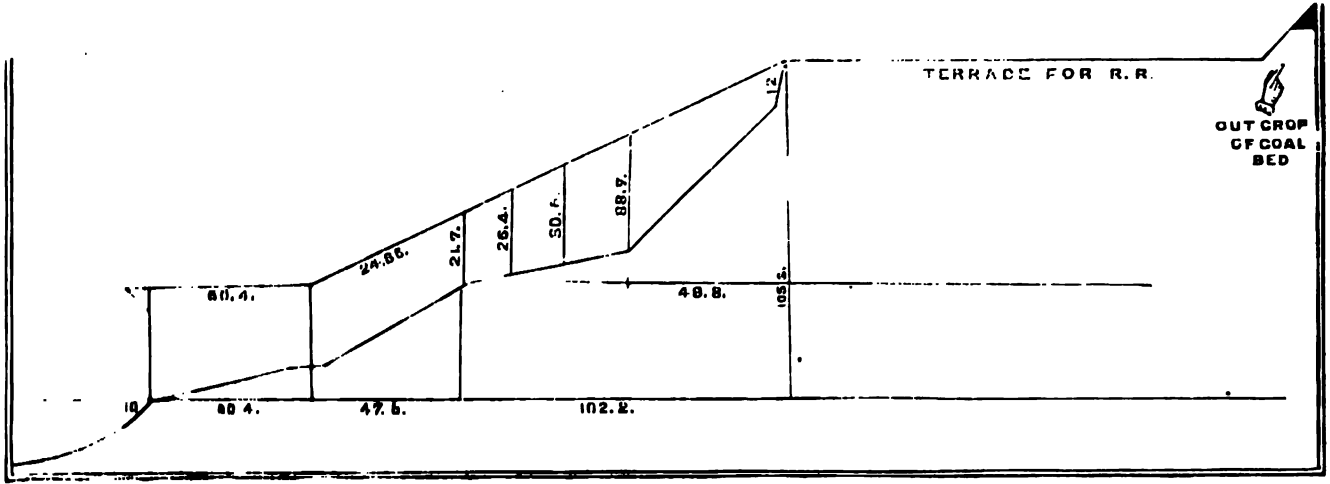
The dips or drainage-lines of this coal-field have been found by many tests of adjacent openings, and where the formation was otherwise exposed, to be on the end line of north 66° west, and the face-line of north 24° east. By diverging at the point A on the accompanying map, 7 in 12 to the west of the face-line, which is south 24° west, a drainage-line will be defined of all coal southeast of said line; and by producing two parallel entries, with a pillar of 21 feet between, from points near the entrance at A, and straight to the point B, distant 416 yards, a second line of drainage can be effected, as exhibited on the accompanying plot; at which point a shaft should be sunk of about 95 feet in depth, and a stationary engine placed thereat. This shaft will answer two great purposes, drainage and ventilation; and by placing a furnace, with steam generator, at or near its bottom, a syphon may be extended 400 yards northwestward along one of the parallel entries, produced from the point A on Rice's Run, for the aggregate distance of 816 yards. See line of proposed syphon drainage on plot. This third line of drainage will conduct all water from the mines, should any exist, as, from the great depth of hill over coal formation and uniform surface, unbroken by ravines, little or no water will be found during the progress of mining; consequently, that division between the line of syphon drainage and the line marked D, on the accompanying plot, can also be mined without the least inconvenience, and the small division of property to the northwest of the line, marked D, being one-ninth of the whole, may either be worked by the aid of mechanical means, as common in all mining districts, or the parallel entries may be produced to Taylor's Run, where a shaft of about 60 feet in depth will effect a drainage of an extensive district of coal-field lying to the south and southwest, and much beyond the limits of that indicated by the accompanying plot.

When the natural advantages of this extensive coal-field are taken into consideration, including depth of water, free from all danger by ice, from its location being immediately below the lock, where boats may remain in safety during the winter months, the uniform depth of hill over coal formation, the advantages furnished by Rice's Run or ravine for the construction of a railroad approach to the works, the short incline to shipping platform, superior quality of coal, and 6 feet 9 inches depth of formation, render this property one of the most valuable on the Monongahela River.

WM. H. BOAL, C. E.

October 28, 1864.

Figure representing the Inclined Plane proposed by W. H. BOAL.



YOUGHIOGHENY

Iron and Coal Company.

Report of J. P. LESLEY *upon the property of* THE YOUGHIOGHANY IRON COMPANY, *situated in Dunbar Township, Fayette County, Pa. March* 9, 1865.

TO H. B. LEECH, ESQ.,
Secretary and Treasurer Y. I. Co.

SIR: I have examined your lands, lying on the waters of Youghiogheny River and Dunbar Creek, where they break through the Chestnut Ridge.

The accompanying map is a reduction from the map by Mr. William Spear, surveyor, and seems to be correct enough for a description of the property. I have colored the ground underlaid by the principal ore bed *blue*, and the ground underlaid by the five-foot bed of coal *sepia*, using a still darker tint to express the ground underlaid by the ten-foot bed of coal, which I shall always speak of in this report by its proper name, the Pittsburg Bed.

The limits of the property are defined by the dotted line; but there are two small tracts, of ten acres and seventeen acres respectively, lying just inside the outcrop of the Pittsburg Bed, and not included in the area defined by the dotted line; of these I will speak separately.

The Old Union Furnace, the site of which is marked upon the map, was built in 1796, and was a charcoal cold-blast furnace, run by the Watts, until a hot blast apparatus was added by Baldwin & Cheney, in the summer of 1855. In thirty-three weeks of 1856, it made 964 tons of metal, and was then changed to a coke furnace, 32 feet high, and run until November, 1859, making, I am told, as much as 2400 tons in one year. The depression of the market rates of iron induced its owners to let it stand idle until the new stack was built, about half a mile lower down the creek, on a wide flat, about three-eighths of a mile from the Uniontown branch of the Connellsville Railroad, where the latter leaves the valley of Dunbar Creek to ascend the valley of Gist's Run.

The new stack is a fine rough-cut sand rock structure, 37 feet square at the base, 43 feet high from the top of the hearth, 10 feet 9 inches across the top of the bosh, and 5 feet 6 inches across the tunnel head; but built so that it can be lined for 12 feet across the bosh. The gaz is taken off by flues, the top of which is 4 feet 6 inches, and the bottom 8 feet 6 inches, below the tunnel head. Gaz pipes descend to the ground, and pass, the one under a set of three 37-foot boilers, the other under a hot air house filled by 12 goosenecks. The hot and cold air pipes are about 12 inches inside diameter, and are served from two vertical overhead blowing-cylinders, 3 feet 6 inches × 5-foot stroke, driven by a horizontal 80-horse engine. Three tuyezes of 3 to 3½ inch. nozzle enter the crucible, 2 feet 6 inches above the top of the hearth, and 3 feet 6 inches below the bottom of the bosh; and the arrangement is intended for a blast of about 3½ lbs. pressure. The ore is carbonate, and the fuel coke from the Pittsburg Bed, mixed, if practicable, with say one-fourth of the coal raw. When the ore is roasted, it is hoisted by a steam ratchet hoist to the tunnel head.

A tramway from the side of the flat on which the furnace stands leads up the southwest side of Irishtown Run (between Dunbar Creek and Gist's Run), 1¾ miles, at a steep grade, to the ore banks which lie about 575 feet above the level of the furnace.

The coal mines are a mile and a quarter distant, by macadamized roads, to the east, with no heavy opposing grade to the furnace, and the coke is made at the mine's mouth, at a level, only about 40 feet above that of the furnace floor.

The limestone quarry is close by the coal mine. The flux of the old furnace was obtained from an abandoned quarry, a mile or so up Dunbar Creek, and its ores from abandoned diggings on the high hills still further up, marked on the map by incline-planes, now in ruins. The new mines are much nearer, and of far easier approach; but the ore is the same.

The metal, when made, will descend the railroad 4 miles to Connellsville, and 57 miles further to Pittsburg, which is the central market west of the Alleghanies.

Chestnut Ridge, where the Youghioghany River breaks through it, just above Connellsville, is a barrow-shaped mountain, with a flat top (so far as the numerous deep ravines have left a top to it), about 2000 feet above the level of the sea, and 1200 feet above the river bed. The Elk Rock, marked upon the map, is by barometer 1450 feet above Connellsville; the Cow Rock, also marked on the map, 650 feet; the furnace, 185 feet; the railroad at Spear's house, or mouth of Gist's Run, 143 feet. Connellsville is about 200 feet above Pittsburg.

Chestnut Ridge is an anticlinal mountain, commencing more than a hundred miles to the north of Connellsville, in Clearfield County, and running on southwards into Virginia. Its inner structure will be understood by referring to the accompanying horizontal section. The Coal Measures of the narrow Ligonier Valley Basin, to the east of it, arch over the mountain, descend its western slope, and plunge deep beneath the country of the Monongahela.

The Mountain Ridge is composed of three or four massive sandrocks, the edges of which form magnificent ranges of cliffs along the sides and tops of the river-gorge, and the numerous lesser gorges of Dunbar Creek and its tributary streams. To speak intelligently of these formations, and the coal and iron ore beds which lie between them, I will call them (beginning at the top) the Ligonier Sandstone, the Mahoning Sandstone, the Dunbar Sandstone, which forms the great cliffs, No. XII Sandstone, and the Pebble Rock of No. X.

The relationship of these great beds of sandrock to those of the Conemaugh and Alleghany country, has an important bearing upon the question of the existence of coal beds in the mountain lower than those opened at the furnace. But I need only say here, that the Ligonier Sandstone is a great deposit of sand and gravel, 50 or 60 feet thick, about 100 feet below the Pittsburg Coal Bed; that the Mahoning Sandstone is the name usually given to the great deposit at the bottom of the Barren Measures, and from 500 to 700 feet below the Pittsburg Coal Bed; that the Dunbar Cliffs are in the proper place for the Freeport Sandstone, which has an immense range north of the Mahoning and Red Bank Creeks; and that the Tionista Sandstone, if it extends so far south as the Youghioghany, may be too thin to notice, or may be confounded with the masses of sandstone on the slopes below the Great Cliffs, which represent, no doubt, the Great Conglomerate, or No. XII, the usual base rock of the Coal Measures.

No. XI red shale formation, with its iron ore and fossiliferous limestone beds, form an arch in the middle of the mountain.

No. X green sandstone formation, with its "bastard limestones" or calciferous sandstones, its petroleum smelling rocks, and its occasional pebble beds form a smaller arch nearer the centre.

No. IX red sandstone formation occupies the centre of the arch in the gap.

No. VIII olive sandstone formation is under water level in the gap; and in it are to be found the Venango County oil-bearing sandstones, if they extend so far south.

The centre of the arch crosses the Youghioghany gorge at or below the site of the lower salt well, and the Elk Run gorge at or about the site of the steam saw-mill, or a little below. But the water level of the river at the lower salt well is 500 feet lower than the water-level of Elk Run at the saw-mill. Therefore, an oil well on the run must be sunk 500 feet deeper than one on the river, to strike the same rocks. The shortest oil well that can be sunk on the property would be one at the river side, half a mile below the salt well, and just underneath the old Bear Wallow ore drifts. The place of the Venango County oil rocks must be a few hundred feet underneath the river bed; but, as no exposures of No. VIII exist anywhere in all Southwestern Pennsylvania, it is impossible to measure the distance down to their oil rocks. The nearest place where they come to the surface is on the borders of Somerset and Bedford Counties, 60 miles east of the property, where they are covered by nearly 1000 feet of No. IX. But we know that No. IX thins rapidly westward, and may not have half that thickness in the Connellsville neighborhood, in which case the top of No. VIII will come up to within 200 or 300 feet of the river level in the gap on your property. I consider it quite certain that a well sunk between 500 and 1000 feet will go through all the Venango County oil rocks, or their representatives; and it will remain for actual borings of that depth to determine whether they contain their proper quantity of oil or not. No geological reason is known for their not doing so, and all the probabilities are in favor of a practically abundant supply of oil from these rocks of No. VIII.

The Dunkard Creek oil seems to come from the Coal Measures, and from no great distance below the Pittsburg Bed. But, in the first place, there is not sufficiently good testimony to establish the fact that they yielded oil in the abundance stated in the newspapers; and, secondly, they may get their oil from fissures penetrating to a great depth.

The Beaver, Lawrence, and Armstrong wells seem to get their oil from just beneath the Conglomerate, or from the top rocks of No. X. But they are so irregular in depth, and so scattered, that it remains still an open question, whether they do not get their oil also by fissures from the Venango County rocks, which lie only a few hundred feet underneath their lower ends.

I have, therefore, for a long time, regarded the gaps in Chestnut Ridge as the best boring grounds in Southern Pennsylvania, and the gaps of the Conemaugh and Youghioghany are cut the deepest of any.

Two salt wells have been bored in the gap at points indicated on the map, and in both of them oil is said to have been found. One well is understood to have been abandoned on account of the outflow of oil. Whatever extravagances may be added to them, these traditions are of great value. The depth of these wells does not exceed 300 feet, I believe.

The "Red Band" or Ore of No. XI is a stratum of blue carbonate of iron, about 10 inches thick, where it has been mined along the brow of the mountain, overhanging the Youghioghany, at the Bear Wallow drifts, 980 feet above the level of the water. About 5000 tons were obtained, during two years, from several gangways, driven through blue black shale, under crowning cliffs of Conglomerate sandstone. It lies in a solid regular slab or flag, and its outcropping edges descend to the river level at the paper-mill, on the one side, and to Dunbar Creek, at the old furnace, on the other. Crossing Dunbar Creek, its outcrop rises with the slope of the sandstones over it, making a line of stripping ground on the west side of the creek, more than 3 miles long, to the south line of the property, then returns, zigzaging up and down both sides of Limestone Run, Tucker's Run, and Elk Run valleys, which enter Dunbar Creek valley from the east, a length in all of about nine miles, and finally adds two miles more upon the river front, descending towards the east. Irishtown Run cuts through the great sandrocks, and exposes two additional miles of ore. There must be about fifteen (15) of ore outcrop upon the property.

Besides the Bear Wallow drifts, there are extensive strippings of the ore on the summit of the ridge between the furnace and the river, and round the headwaters of Elk Run,* at elevations of 880 and 1150 feet above the furnace. An old tramway once brought the ore to the furnace from Kree's incline, on the south side of Elk Run, 500 yards above its mouth. The incline went to the top of the mountain, to two beds of ore, 40 feet apart, the lower one called the Big Bottom ore, and the upper one distinguished by the name of Honeycomb ore, although its structure is simply that of a layer of balls of blue carbonate, occurring near the top of the mass of shales, in which the whole ore deposit is contained. There were here three regular plates of the ore: one, 14 inches thick; a second, 10 inches; and a third of small size, near enough to work in a common-sized gangway. But, up to the time of the blowing out of the old furnace, the ore was stripped, and the stripping at this place had got to be so heavy, that drifting would have been quite as cheap.

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* The old trenches are hundreds of yards in length ; the ore is a fine pea ore, partly hematized, called by the miners here the "little honeycomb ore;" but it is a ball carbonate, in shale, at the summit of a hill or nose, 420 feet high, splitting the waters of Elk Run, just above the saw-mill, and composed of sandy shales of No. XI from top to bottom.

Another incline (Watts's) led up to the outcrop of the ore at the point of the mountain between Tucker's Run and Dunbar Creek. These works, also, are at present abandoned.

The new tramroad is carried a mile and three-quarters up Irishtown Run, from the furnace to the outcrop of the ore, at an elevation of about 600 feet, where all the present mining is done, and where the deposit exhibits essentially the same aspect. In the face of the stripping, which is about 20 feet deep at the face, is seen at the top a layer of ball ore, some of the masses coming out a foot long, and four or five inches thick, but never consolidating into a regular plate. At the bottom lie three layers of ore, sometimes splitting into four or five, but always measuring about the same total thickness of ore, about 2½ feet. There is a top layer of hard, heavy clay iron-stone, or very argillaceous protocarbonate, running 8 or 10 inches thick, on 6 to 18 inches of nearly black fire-clay slate. Then comes a middle layer of dark-blue, soft, argillaceous ore, resembling in appearance a bed of ferruginous fire-clay, on 4 inches of soft blue slate. Finally, there is a bottom layer of hard blue carbonate, of fine grain, and disposed, like the top layer, to come out in slabs or flattened nodules of large size, and entirely contiguous, on 12 inches of slate. Under all, come gray, flaggy sandstones.

Where there are five layers, the soft ore continues to be the principal one, about 12 inches thick, and the other four are 6 or 7 inches thick. These openings, with old drifts running from them into the hill, date back thirty years, and furnished ore in summer, while the incline planes were only used in winter. But the principal amount of work done here was done in 1857 and 1858. There has lately been enough fresh stripping done to uncover several thousand tons, ready to raise, and some of it already raised and stacked, ready to go down the tramway.

On the opposite mountain, east of Irishtown Run, there are other openings of the ore, carried up to a much higher elevation by the rise of the rocks towards the central axis of elevation.

There must have been about 120,000 tons of ore mined at different points along the extended outcrop, during the last sixty years, and the miners report the bed to be sometimes found in one solid layer, three feet thick, or with a thin parting of slate, which sometimes thickens to several feet. In one instance there was 3½ feet of solid ore in one layer, for a space of fifty yards, and then it parted into two, and afterwards into several layers.

The balls of beautiful fine-grained carbonate which come out of the top edge and upper slates of the stripping, arrange themselves sometimes in two or three layers, and will yield from 1½ to 5 tons of ore to a ten-foot area. Whereas, the principal deposit, or Big Bottom ore, will yield 1½ to 2 tons per square yard of stripping.

The ore is a 30 to 40 per cent. carbonate, making a ton of iron out of from 2¾ to 3¼ tons of ore. Its iron is somewhat redshort, and would be improved by being mixed with Lake Superior ore, in the proportion of from 20 to 30 per cent. of the latter. The experience of other coke-furnaces proves that 20 per cent. of Lake Superior ore will enhance the market value of iron of this kind. A small mixture of the titaniferous ores of Canada, which come to Pittsburg, would be an additional improvement to the quality of iron made. At the same time, the heavier ore is well known to improve the yield of the lighter ores, and thereby increase not only the reputation, but the production of the furnace.

The cost of making iron at present prices (nearly at the double of prices four years ago, may be approximately arrived at thus:

3 Tons of ore mined	@ $2 [illegible]		
" " " hauled to furnace	@ 1 [illegible]		
" " " smelted	@ 1 25		
	$[illegible]	say	$8 00
130 Bushels coal mined	@ $1 [illegible] per ton.		
" " " coked	@ 1 [illegible] "		
" " " hauled	@ 1 [illegible] "		
	$[illegible]	say	[illegible] 00
1½ Tons of limestone quarried	@ $[illegible] 00		
" " " hauled	@ 1 [illegible]		
			[illegible] 00
Furnace labor of all kinds about the stack			[illegible] 00
			$2[illegible] 00
Transportation to Pittsburg	$2 50		
Handling three times	[illegible] 50		
			[illegible] 00
Actual cost at Pittsburg			$24 00

At present the Lake Superior ores are sold in Pittsburg for $16, and they make a ton of iron from 1½ of ore. At Dunbar they would cost $18.50, and at the furnace, $19. Labor remaining the same, but the quantity of Big Bottom ore and limestone being diminished, with an increased yield of metal and improved quality, it is easy to calculate the profit on the make, with the best iron selling at $40 to $50 per ton.

125 Tons of ore, as above,	say,	$8 00
60 Tons Lake Superior,	"	11 50
Coal, as before,	"	5 00
1 Ton limestone,	"	1 50
Labor, as before,	"	6 00
Total cost of iron,		$27 00

In this case, as much as one-third Lake Superior ore is supposed to be used. By graduating down the quantity of Lake Superior ore used, the exact cost of smelting native ore unmixed could be obtained, but with an enhancement of the market price, varying from $5 to $10 per ton.

In some cases, the improvement of the iron by a small mixture of titaniferous ore is very remarkable.

The Five-foot coal-bed, under the Mahoning sandstone, is opened on both sides of the creek, near water-level, at the furnace, and on the slopes of the hills, at several points of the ascending outcrops of the bed, to a height of over 500 feet. It lies about 100 feet above the Three-foot coal-bed, which lies about the same distance above the Big Bottom ore bed. The Five-foot coal has been used for farming purposes, and would do very well to roast with, and could be mined cheaply and close at hand. But the main dependence of the ironmaker, in this region, is upon the great Ten-foot bed, or Pittsburg bed, five or six hundred feet higher in the measures.

This noble coal-bed, which extends in a solid sheet from Connellsville to Wheeling, and from Saltzburg to the Cumberland River, and the isolated fragments of which, in the Ligonier Valley, in Somerset County, in the Cumberland Coal-basin, and on Broad Top, testify to its former existence over a far greater area towards the east, and in Western Kentucky towards the west, is in its prime along the Connellsville Railroad. At Pittsburg, it yields but five or six feet of coal, and that too sulphurous to make the best coke. As it ascends the Monongahela, it improves in thickness and quality. Most of the coke now used in Pittsburg comes from this bed, opened along the Youghioghany. The quality of the coal steadily improves up the river, and nothing can be better than Connellsville Coke. The bed outcrops along the hills facing Gist's Run, as shown by the darkest tint on the map. It is about eleven feet thick, and dips from about one foot in six to about one in ten. The miners leave about ten inches of coal to hold up the clay-slate roof, and take out seven or eight feet of solid coal. The roof is regular, while the floor rises and falls in places from an inch to three feet, producing "swamps." On the rolls, the whole thickness of the bed is sometimes only eight feet. A bearing-in-slate, of about one inch thickness, runs three to four feet above the floor, and a second one eight inches higher; the coal is first mined between the two.

The Company has a ten-acre lot underlaid by this bed, a mile west of the furnace, four acres of which are said to be mined out already. The remaining six acres ought to yield 500,000 (five hundred thousand) tons clear. The level gangways run lengthwise of the lot, and their mouths are 50 and 80 feet above Dunbar Creek, where the coal-wagon road crosses, and about 10 and 40 feet above the actual level of the furnace. The coal is coked before the gangway mouths.

The Company owns another seventeen-acre lot on the outcrop of the same bed, two miles down the railroad, towards Connellsville. This is intended for a colliery and coke-yard; the coke to be let down from an elevation of say 200 feet upon the

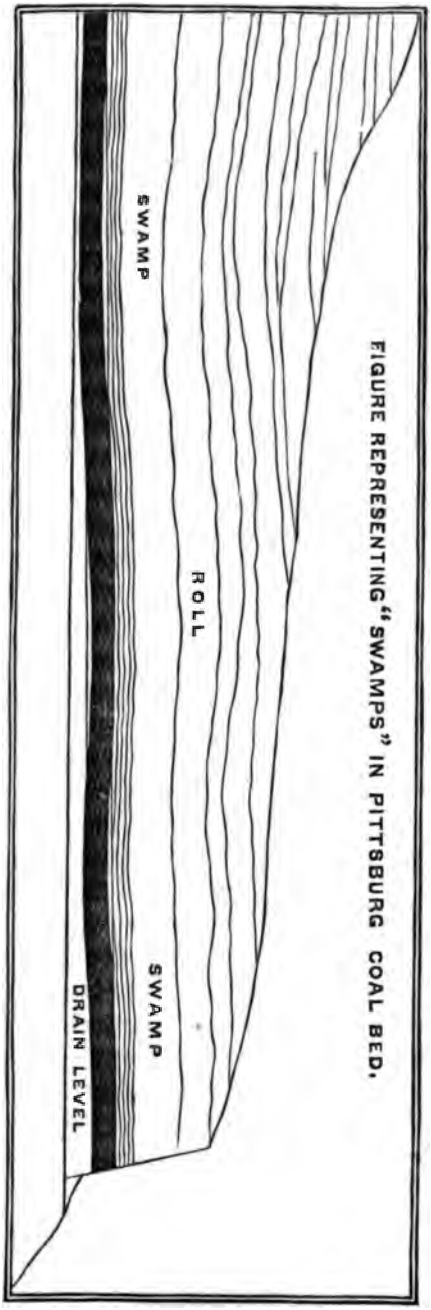


FIGURE REPRESENTING "SWAMPS" IN PITTSBURG COAL BED.

railroad, and brought up thus to the furnace, especially in wet seasons.

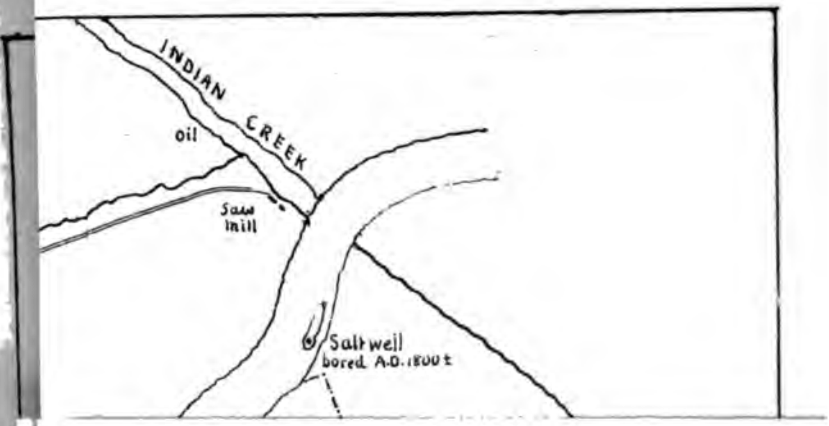
Limestone strata underlie the Pittsburg coal-bed, at a depth of 20 to 40 feet, and crop-out in the neighboring fields, where they are lifted and taken by the coke road to the furnace.

It is needless to refer to the existence of the lower limestones, because they are not required for use. One large outcrop is seen 90 feet below the Big Bottom mines, at the head of the tramway. Fossiliferous limestones have been quarried at a vertical depth of 300 feet below the place for the ore, on Dunbar Creek, above the old furnace. The extended outcrops of these two deposits I have not placed upon the map, because they would have confused the other data, which it was more important to show.

The Great Cliff Rock, when it approaches the northeast end of the property, takes on the character of a glass-sand, all good qualities of which have now a high market value. The Elk Rock itself is a remarkable object, as it stands on the summit of the mountain, slowly melting away under the action of the frosts, rains, and winds. Piles of glass-sand, some of it very white and pure, lie about it, and have had a limited sale in Pittsburg.

Timber is heavy on the eastern part of the property, and is growing on almost all of the 5000 or 6000 acres. In twenty years there would be enough to run a charcoal furnace with continuously.

I remain, sir,
Very respectfully,
Your obedient servant,
J. P. LESLEY,
Topographical Geologist,
1016 Clinton Street, Philadelphia.



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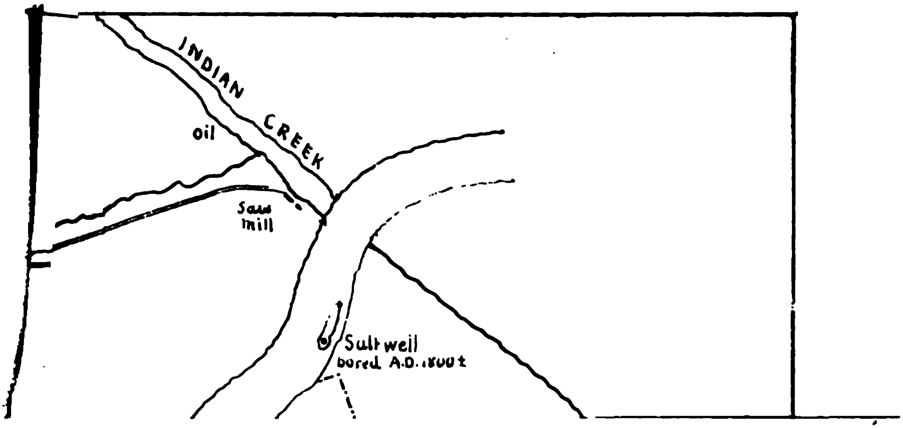
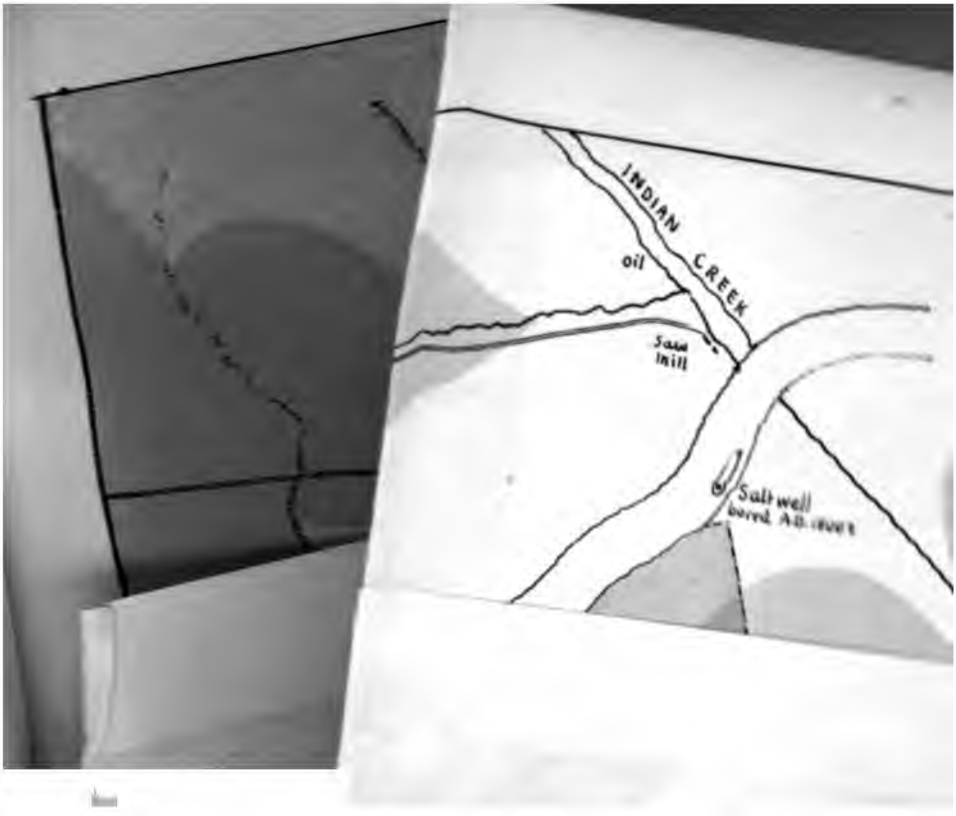

INDIAN CREEK
oil
Saw mill
Salt well
bored A.D. 1800±


INDIAN CREEK
oil
Saw Mill
Salt well
bored A.D.

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GEOLOGICAL REPORT

ON THE

Brady's Bend Iron and Coal Company's

LANDS

IN

ARMSTRONG COUNTY, PENNSYLVANIA,

BY

J. P. LESLEY.

1865.

REPORT UPON THE BRADY'S BEND IRON CO.'S PROPERTY.

BY J. P. LESLEY. TOPOG. GEOL.

Brady's Bend Rolling Mill, situated on the west bank of the Alleghany River, at the mouth of Sugar Creek, 16 miles by land and 25 miles by water above Kittanning.* 55 miles by land 71 miles by water above Pittsburg, in Armstrong County, Pa., was built in 1841, has 25 puddling furnaces and 10 heating furnaces, and five trains of rolls, making, in 1856, 7533 tons of railroad iron.†

Brady's Bend Steam Hot Blast Coke Furnaces, Nos. 1 and 2, 3 and 4, standing on the south side of the creek, a mile above the Rolling Mill, were built, No. 1 in 1840, No. 2 in 1841, No. 3 in 1843, No. 4 in 1846; No. 4 for a charcoal furnace. With coke they make about 100 tons of metal per week each.‡

These Furnaces depend for their stock upon strata of ore, coal, and limestone in the surrounding hills, and on an extensive and well-planned system of gravity railways, which bring down the ore, the fuel, and the flux, from mines and quarries, opened at various elevations, ranging from 200 to 400 feet above the river, and within a radius of two miles.

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* The Alleghany Valley Railroad terminates at present at Kittanning, but is graded to mouth of Mahoning, and will be in running order as far as mouth of Red Bank in fall of 1865. This point is within 4 miles by land and 5 by water of Brady's Bend Works.

† Amer. I. Man. Guide, p. 252.

‡ In 1856, No. 1 made 5391 tons of coke iron, and No. 2, 5576, being 14 and 13 feet bosh and 50 feet high. No. 3 and 4, 11 and 9 feet bosh and 43 high, made, No. 3, 1745 tons in 18 weeks of 1854, and No. 4, 218 tons in four weeks of 1855, charcoal forge iron. At the present moment the round furnaces are out of blast.

For other and more recent details of these works, see the pamphlet published by the B. B. Co., New York, 1864, p. 8, ff.

The ores consist of two kinds found in the coal measures: 1. Clay-iron-stone beds, in balls and in plates; 2. Brown-hematite deposits, segregated from strata of ferriferous clay and sandstone.

The coals are bituminous; coked on yards in front of the gangway mouths.

The limestone is benched down in masses, at small cost, and is chiefly argillaceous, and somewhat ferriferous.

These strata belong to the lower coal measures of Western Pennsylvania (the middle coal measures of the United States), and lie between the Conglomerate No. XII, in the river bed, and the Mahoning Sandstone (the base of the barren measures) on the tops of the highest hills.

Four systems are here represented in descending order as follows:

1. The Freeport System.
2. The Clarion System.
3. The Tionista System.
4. The Mercer System, at the bottom.

But of these four, only the first and second are of importance in this region of Brady's Bend.

The Freeport System is made up of (neglecting the small and unimportant members):—

1. The Elk Lick Coal Bed.
2. The Upper Freeport Coal Bed.
3. The Freeport Limestone.
4. The Freeport Limestone Ore Deposit.
5. The Lower Freeport Coal Bed;

and its well-marked base is everywhere a more or less massive sandstone stratum called the Freeport Sandstone. From this system the Brady's Bend Furnaces are chiefly supplied with coal and ore, at what are called their summit mines, and also with a superior kind of fire-clay, for fire-brick, called whetstone, with which to build their inwalls and puddling furnaces.

The Clarion System is made up of the following principal beds:—

1. The Upper Kittanning Coal Bed.
2. The Lower Kittanning Coal Bed.
3. The Buhrstone Ore Deposit.
4. The Great Ferriferous and Fossiliferous Limestone.
5. The Clarion Coal Bed;

and its well-marked base is the Tionista Sandrock, here lying about 150 feet above the water-level of the river. From this system the Brady's Bend Furnaces get their flux stone, and some of their fuel, but very little ore, except at one place where their "slab ore" is mined; the true buhrstone ore being thin on this side of the river, and only mined in connection with the top layer of the limestone quarries.

The Tionista System is represented by some very thin coal beds among the sandstones which rise from the river bank, and is not clearly distinguishable from the Mercer System near the level of the river, beneath which the Conglomerate No. XII lies at no great depth or in the river bed.*

Brady's Bend occupies the exact geological centre or deepest part of the sixth and last Bituminous Coal Basin, counting from the Alleghany mountain northwestward towards Lake Erie and the State of Ohio. Its rocks, therefore, would be perfectly horizontal but for three things which happen to prevent: 1. The gentle northwest and southeast dips, from the two sides of the basin, in towards its centre line; 2. The extremely gentle settling of the whole basin southwestward towards the Ohio River; and 3, less gentle local variations of dip, produced by a system of almost invisible cross waves, at right angles (approximately) to the basin itself.

The first of these disturbances causes any given bed at Brady's Bend to take a more and more elevated outcrop-level around the hills, when followed *down* the river as far as the old American Furnace (10 miles), where the fifth or Kittanning Basin begins its southeast dip, and also around the hills, when followed *up* the river towards Franklin and the Meadville Highland, so that the Tionista coals, which, at Brady's Bend, are near the water-level of the river, cap the highest hills around the mouth of French Creek.

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* F. R., 577.

The second disturbing cause produces the same effect in a northeasterly direction, carrying up the Tionista coals into the highest hills of Elk and McKean Counties, and plunging them 500 feet deep beneath the Ohio River at Pittsburg.

The third set of disturbances are purely local, and produce those swamps and rolls in the mines of which the miners complain, and they affect also very much the course of the smaller ravines and vales, determining the sinuosities of Sugar Creek, and even the curves of the great valley of the Alleghany River itself. The curious bend in the river, ten miles around and three-quarters of a mile across at its neck, is due to the river having here found the centre of the VI Basin; but the determination of the cliffs below the Rolling Mill has been made by a local dip from the river front, southwestward (instead of northwestward) into the valley of Snyder's run branch of Sugar Creek. The swamp in the ore mines at the head of the inclined plane is produced by this and a counter local dip meeting it from the southwest.

Practically, the high hills between the branches of Sugar Creek and the river are built up of horizontal strata, making mining very easy, and exhibiting a country for mining purposes almost entirely undisturbed and in its original condition. The crust of the earth is traversed by numerous nearly vertical cracks, the general direction of which, where I saw them best, is not far from east and west; but these cracks cannot be thought to penetrate more than one rock or one system of rocks at a time, or they would have inevitably thrown one side of the crack up and the other down, producing vertical faults in the coal beds. They must, therefore, be considered as shrinkage-cracks on a large scale, confined to the rocks in which they occur, and determined in their direction partly, perhaps, by electricity and magnetism common to all parts of the crust, but chiefly, as I believe, to the local strain of the dip, and the local composition of the stratum.

The law governing the number of these cleavage-planes is a simple one; the distance of the clefts from one another is, in the main, proportionate to the massiveness of the strata which they divide; that is, the cleavage-planes of the great beds of massive sandrocks lie much further asunder than those of the thin-bedded sandstones; while those subdividing beds of shale are still closer to each other and more numerous. We may state the law in another way: the coarser the materials of a stratum, the larger are the cubes into which it is subdivided where it lies, and the huger the blocks which fall from its outcrop edges down the hill-slopes. Hence the vast blocks which encumber the steeps of the Alleghany, wherever the erosive agency has acted forcibly upon the Mahoning, the Freeport, the Tionista or the Conglomerate sandrock formations.

The law governing the size or width, and also the length and depth of the fissures, is an analogous one:—the great sandrocks exhibit clefts sometimes many inches in width and running many yards or hundreds of feet continuously. The pressure of these rocks sometimes carry their cracks down (or up) through the softer and thinner beds, and the strain of the dip will even cause these cracks to descend many fathoms below where they originated.

Clefts in sandrocks, as a general thing, must remain more or less open, and are the great channels of underground drainage; whereas the fissures in the shaly mudrocks have been closed as fast as made by the plasticity of the whole mass, and by the perpetual percolation of fine clay into them. Those which penetrate coal beds, for instance, are almost all filled up with clay from the overlying shales; while many of the fissures in the coarser sandrocks are only choked with loose sand or small water-worn pebbles. All these are permanent reservoirs of water.

Clefts in limestone rocks, on the contrary, permanently tend to enlarge themselves, because the surface waters contain carbonic acid in solution, and this dissolves away the walls of the fissures, and rounds off the edges of the limestone blocks. The great ferriferous limestone, 15 feet thick, has become everywhere a perfect labyrinth of caverns. In these the early settlers built saltpetre furnaces. At Sarah Furnace, and elsewhere, the ore which lies upon the limestone, is traced by following these natural catacombs. In some parts of the country, the ore itself has been carried off through these cave-passages and totally lost. The great subcarboniferous limestone of Kentucky is famous for its complicated caverns, and many of the valleys which lead out through it into the Blue Grass Country have no running streams; but never-failing mill-stream springs issue from the outcrop of the lowest stratum of the limestone into the low country to the west. Wherever the limestone is sandy and ferruginous, the decomposition and mechanical dissolution of the rock has gone on with yet greater facility, and caverns are still more abundant and extensive.

If the subcarboniferous limestone formation, which is 400 feet thick on the borders of Tennessee, had anything like that thickness in N. W. Pennsylvania, Brady's Bend would be underlaid by a world of gigantic caverns, affecting greatly the drainage of the country. But the formation here is only four or five feet thick, and, therefore, is of even less importance in this respect than the ferriferous limestone of the Clarion System, except that, as it underlies the river bottom at a depth of one or two hundred feet, it may be a reservoir of oil and salt water.

There are always two systems of cleavage-planes, and a third is added when the rocks are much uptilted. One of the two is always far better defined than the other. In the neighborhood of Brady's Bend this major or primary system has its planes running S. 80° W., N. 80° E., and dipping 70° towards the south. The minor or secondary system has its planes running nearly at right angles to the other, and dipping irregularly 60° towards the east.

Keeping in mind these facts as they appear above the water-level of the Alleghany River at Brady's Bend, and taking for granted that they are represented by similar facts below that water-level. I will now describe the formations through which the oil well will descend which the Company is boring on the river bank a few hundred yards north of the Rolling Mill. These are in descending order as follows:

No. XII. The Great Conglomerate or mill-stone grit, the base of the lower (or middle) coal measures, a coarse-grained, loosely-cemented sandstone formation, usually found (in N. W. Pennsylvania) in two layers, the upper one 15 to 20, the lower one 30 to 35 feet thick, with shaly sand beds in between, charged with nodules of iron ore; sometimes capped by a layer of true conglomerate made up of rounded pebbles of quartz; when it rises above water-level, weathering down into a dry whitish glassmaker's sand, supporting a stunted vegetation, and always marked by a belt of evergreens and laurel-thicket; the surface of the rock, weathered otherwise into circular blotches and pits, or covered by a curious reticulation of small ridges; yielding good hearth-stones, splitting easily in all directions, and covering the slopes below with masses of rock as large as log cabins. This is the formation which caps the river hills towards Franklin, and forms wide stretches of barren glade lands towards Lake Erie. To the west it forms the beds of the Beaver River and the Conneconessing, and to the southeast it forms the summit of the Alleghany Mountain, and the top-covering of Chestnut Ridge and Laurel Hill, far into Virginia. It contains the remains of plants, and sometimes small lenticular patches of coal an inch or two in thickness. Its pebble-bed is undoubtedly often charged with oil, which no doubt frequently fills its fissures also. But its proximity to the surface in Western Pennsylvania has permitted most of its hydrocarbons to escape, or be dried up into bitumen. In Southwestern Pennsylvania it may be a reservoir of oil.

No. XI, Red shale, 3000 feet thick under the anthracite coal basins of Eastern Pennsylvania, is less than 100 feet thick in the region of the Alleghany River. At the top of it is a bed of iron ore, sometimes two feet thick, and at others subdivided into five or ten small separate layers, making up about the same total quantity of ore. At the bottom of it lie the Lowest Coal Measures, quite a system in Virginia and Kentucky, but here a single bed of very small size or a mere stratum of scattered flakes and patches of coal a few inches in thickness. In some parts of Northern Pennsylvania there is a foot or so of coal found with the iron ore at the top of XI, just underneath the conglomerate.

No. X, White sandrock, 2000 feet thick in Eastern Pennsylvania, is also so thinned out before it reaches the Alleghany River, that it shows scarcely more than 200 feet of greenish sandstone, thin-bedded, false-bedded, and sometimes charged with numerous plant remains. At the top of this formation (or at the bottom of No. XI) occurs a limestone, which may be recognized from the State of New York to the State of Alabama, and is several hundred feet thick in Kentucky, as above described, when speaking of caverns in limestone. At the head waters of the Alleghany River it lies about 200 feet below the conglomerate, and is 4 feet thick, covered with hard white sandstone belonging to For. X.* It is exceedingly fossiliferous, being in fact a sandstone filled with fossil shells. On the Youghiogheny it is many feet thick. It must underlie Brady's Bend at a depth somewhat over 200 feet. Taken in connection with the calcareous sandstone and coarse conglomerate sandstone layers near the top of No. X, I think it will be proved to be the true horizon of the oil which is obtained by the wells at Kittanning, Freeport, and Tarentum, on the Alleghany, and at Brighton and other places on the Conneconessing and Slippery Rock Creeks, and Big and Little Beaver Rivers. The first oil shown by the Brady's Bend well will probably come from this depth ; that is, between 200 and 400 feet, according to the condition of the rocks of X at this locality, and according as the auger happens to strike some master fissure in X at a higher or lower level; for we must suppose that the fissures of X slant at a similar angle with those of the Freeport and other sandstones above water-level. All these rocks, with some to be described below, crop out high up along the hillsides of Oil Creek, French Creek,

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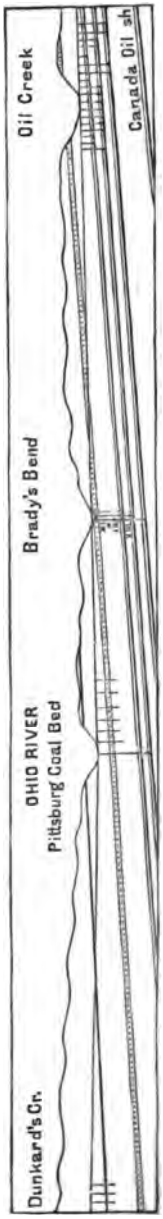
* F. R., p. 547, 550, 554.



and the upper Alleghany waters, and have nothing whatever to do with the oil production of that region, bearing, in fact, the same locally barren relation to the productive Beaver and Butler wells that the barren outcrops high up along the Freeport river hills do to the productive wells of the upper Monongahela and Dunkard's Creek region. This alone is sufficient to expose the want of knowledge of those who are always prating about the first, second, and third sandrocks. These are, in fact, a peculiarity of the Oil Creek region, as I will more fully describe further on. The fact is, every formation which has been originally replete with fossil life, animal and vegetable, has been a reservoir of petroleum; and every such formation, when lifted to a level above the valley beds, has lost its petroleum by evaporation and percolation; but every such formation, where it has remained deep buried beneath the present surface drainage, and covered by other clay formations, has retained its petroleum in its gravel-beds, loose sands, and vertical fissures; and the more of it in proportion to its depth and to its gravelly, massive, and fissured character. No. X attracts no attention at all on the upper Alleghany. It will probably yield a rich harvest on the lower Alleghany and Ohio Rivers. Any one who will take the trouble to study its outcrops in our northern counties, and in Southern New York, will see how its 150 or 200 feet of rocks include numerous pebble beds and multitudes of fossils.*

No. IX, not far from 2000 feet thick, on the Schuylkill River, is scarcely recognizable on the Alleghany waters.† A bed of red shale, from 10 to 50 feet thick, is all that remains of it in McKean and Mercer Counties, and the green flaggy sandstones of X above it, and of VIII beneath it, are so much alike that the identity of this red-shale band with the vast Old Red Sandstone of the east, is by no means certain; especially as another and larger red-shale stratum occurs 200 feet lower down in VIII, bearing the iron ores of Mansfield on the Tioga River. Yet I have no doubt that, if a careful record of the Brady's Bend well be kept, some evidence of the existence of Formation IX, red shale or red sandstone, as the case may be, will be obtained, say at the depth of 300 or 350 feet, especially as I believe the formation can be seen throughout Northern Ohio, and seems to be represented even in the artesian well at St. Louis.*

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* F. R., p. 547.

† Idem.

No. VIII, 8000 feet thick in Eastern Pennsylvania, is the great formation of all Southern New York and Middle Ohio; forms the bottom and sides of most of the valleys of the Pine Creek, Sinnemahoning, and Upper Alleghany waters, and is the principal home of petroleum, both in the United States and in Canada. It. forms the lower parts of the hillsides of Oil Creek; and the wells of that region would have to be sunk 3000 feet at least to reach its bottom layers, resting on No. VII. It may be subdivided into two great members, the upper one more sandy, the lower one more shaly; and in this lower member, far down towards the bottom, are the black slates of the Genesee River and the limestones under them, from which the wells in Canada and Michigan get all their oil; while in the upper one occur the "three sandrocks" of the Oil Creek wells. So that the Canada oils and the Pennsylvania oils are of very different ages, the Canada oils being much the oldest.

In the Oil Creek region Formation VIII consists of alternations of almost perfectly horizontal greenish and olive colored sandy mud-rocks, olive shales, and white sandstones, the three principal layers of which, each about 30 feet thick, capped by a foot or two of fine pebble rock, with a top coating or crust of silex, two or three inches thick and excessively hard, lie at the depths of 200, 400, and 600 feet, or thereabouts, respectively, beneath the level of Oil Creek. The early wells were mostly bored down only to the first of these, and obtained large quantities of heavy petroleum. Subsequently, hundreds of wells were sunk to the second rock, and most of the later wells to the third, from which enormous quantities of the lightest oil are still obtained. How far these sandrocks extend is not known. The third sandrock seems to fade away towards the north, and the Titusville wells are sunk to much greater depths. In the French Creek valley and its tributaries, the first and second rocks have been the principal reservoirs of petroleum. The dip of all the rocks from the Lake Erie Highland being exceedingly uniform and slight towards the southeast and south, in fact scarcely differing in degree from the fall of the level of all the streams which feed the Alleghany River, and in the same direction, the depth of the thousands of wells already sunk is very uniform. But from Franklin down to Brady's Bend the dip of rocks exceeds the fall of the river bed, and all the rocks of the Franklin hills descend gradually to the river level and bury themselves to depths proportional to the distances. The Conglomerate No. XII, which is 500–550 feet above Oil City, reaches water-level at Brady's Bend or a few miles above. The first sandrock, which is 700–750 feet below it on Oil Creek, must, therefore, be, say 750 feet beneath the river bed at Brady's Bend, the second sandrock 950, and the third sandrock, if it exist so far south, 1150, more or less. This is taking for granted, what is very probable, but not certain, that the three sandrocks maintain a uniform distance from one another all the way. The quantity of oil that they contain must be left an open question for experiment to determine; but it seems certain that even the first sandrock, when buried to a depth of 750 feet, must contain *light* oil instead of *heavy*.

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* Manual of Coal, p. 218 and 65.

We know so little about the genesis of the oil, and have so very imperfect a conception of the facilities and forces of the deep-underground drainage, that it is almost useless to speculate upon the subject. The main point is, that the oil is in some way collected and sustained by the salt water, which itself has been produced by the percolation of rain and river water through thousands or rather millions of cubic feet of rocks, deposited in a former salt ocean, and, therefore, wholly impregnated with salt. The hydrostatic pressure of this water upon every particle of rock, and every square inch of every fissure wall, brings it to the surface whenever a chance is afforded it to rise—whether by occasional natural cracks of unusual magnitude extending to the surface, or by artificial holes made with boring tools. And to this is added the force with which the gases, chemically disengaged from the petroleum, press upon both rock and water to escape. In the sandrocks and gravel-beds, no doubt, all three elements, salt water, oil and gas, remain mechanically combined. But in the same ramifying caves of limestone, and in the quasi fissures which penetrate the sandrocks, they are separated by specific gravity into three places, the gas occupying the upper, the oil the middle, and the water the bottom of each cavity. Wells which happen to strike the slanting fissures near their upper limit must blow gas; those which encounter them midway flow oil; and those which strike them near their foot must pump salt water before they can get much oil or gas. Such is the only probable explanation of the facts in our possession. The more copious wells are no doubt all of them in communication with fissures, as in fact the dropping of the rods often proves. But the sand and gravel-beds are themselves sponges, saturated with oil and water, and permit a feeble circulation of these fluids through their entire extent, produced, perhaps, chiefly by the *vis a tergo* of gas, but also necessitated by the laws of hydrostatics. These spongy oil rocks are enormous reservoirs of petroleum, which it is impossible to exhaust for many years, as a simple calculation will soon show.

Every foot of gravel rock may be considered to consist of three-fourths quartz &c. and one-fourth cavity, cleaned out by long percolation and now occupied by water and oil. The proportion which the oil bears to the water in the bed is unknown, but must be far greater than in the whole 30 feet of sandrock at the top of which the gravel lies, for the oil will settle in these top layers of gravel, while the water remains in the body and lower layers of the sandrock. If the proportion in all be 1 to 100 (for the sake of the calculation), the proportion in the gravel may be 1 to 10, and in the few inches at the extreme top, even 10 to 1. If we should suppose only the uppermost four inches of the whole sandrock mass charged with pure oil, that would give an absolute layer of oil one inch thick underspreading the whole country as far as the sandrock extends, to about 4000 millions of square inches under every square mile, or in other words, 17⅓ millions of gallons=551,706 barrels. *Each sandrock* should be able to supply from *each square mile* of its area, the whole present oil produce of the United States for ninety days before it is exhausted, and that without any reference to the accumulation of petroleum in fissures.

Some of the main fissures are known to be four inches wide. Suppose them to be of all sizes, from four inches to a quarter of an inch in width, and at various distances asunder, from 5 to 50 feet, and to be limited to the sandrock itself, say 30 feet in height, then we will have the contents of the fissures equal to, say $\frac{1}{300}$ the mass of the rock. And supposing the oil to occupy but $\frac{1}{10}$ of the space in each fissure, the rest being occupied by water and gas, we have a yield of oil from each square mile of each sandrock, in addition to that above, amounting to nearly 50,000 barrels of oil. This is at the lowest calculation. In a case like that of the Noble well, yielding one or more thousand barrels of oil per day, for a year or years, we have only to imagine a single four or five inch fissure crossing the upper and lower rocks to a height or depth of one or two hundred feet, and extending a mile or two in length, the oil contents of which will amount to millions of barrels, apart from all side supplies. Along the line of one such fissure, it is easy to see that a dozen first-class flowing wells might last for several years. By ordinary wells it would be practically inexhaustible.

The number of first-class flowing wells is as yet very small. I judge that not more than one well in ten or twelve yields more than a barrel a day, because the large majority of wells depend for their supply upon the slow circulation of the mingled fluids along the sandstones, through which, or down to which, they go. Hence, the necessity for carefully protecting this circulation, and the utter ruin to the interest of wells which is produced by letting down the fresh water from the surface to mingle with, dilute, and drive back the salt water and oil from the neighborhood of their lower ends. To prevent this calamity, the ingenious seed-bag was invented, and to place this stopper at the proper point so that the fresh water may not pass around it downwards requires all the skill of the experienced borer, and the rules governing its location must be worked out anew in every new locality. Hence, the importance of making and keeping a careful register of every well as it is sunk, the depth and thickness and character of every stratum bored through. In the bustle and impatience of oil speculation, too little attention has been paid to this, and a large amount of invaluable information has, in consequence been lost. I shall be glad to receive and publish all authentic and reliable records of new or old borings, which are sent to me properly certified, for the benefit of society in general, and accurate science in particular.

If the Brady's Bend Company see proper to bore down through all the sandrocks of No. VIII, in their first well, they can use the knowledge thus obtained, in boring other wells upon their territory; and if they carry down their boring to the Genesee black slates, to try for the Canada petroleum, they will confer a great benefit upon science and obtain an additional production of petroleum.

The Valley of the Alleghany is, of course, the best place.to begin boring, because it is the lowest level and requires shorter wells. But the erosion of the valley has nothing whatever to do with the general distribution of the oil; and they may bore with equal success in the beds of Sugar Creek and all its branches. So far as the horizontal reservoirs are concerned, it will be adding only so many feet to the depth of the boring. As for striking fissures at any given depth, that is a perfect game of chance, not the shadow of a rule exists. Neither have the breaks in the hillsides anything to do with it, as some fancy. These are all surface accidents, determined chiefly by the local dip and not by the fissuring of the rocks. There are no "belts of oil" as some imagine, distinguishable upon the surface. There are belts of sandrock, or, rather, of gravel layers in the sandrocks underground, just as there are rockfaults and rollfaults in coal beds. But these are the products of ancient currents in the sea at the time the sandrocks were deposited and obey no law which we have succeeded yet in discovering. They are strictly local, and so small as scarcely to be shown upon a common map of the State. The belts of wells have been caused by the fact that they are sunk in valleys, and that they have clustered along certain outcrops in order to avoid the need of going down to inconvenient depths. All straight-edge locations of wells upon a map are mere charlatanry.

To return to the coal measures of Brady's Bend, they consist of the following rocks and minerals in the following order:

Elk Lick Coal, on the highest ground back from the river, 5 feet thick; this bed becomes ten feet thick in Jefferson County: it is not mined on the Company's property.

Shale and Slate interval of over 60 feet.

Upper Freeport Coal, called the "summit vein," and mined for coking, consists of four benches, 1st, top bench, 12 inches; fire-clay and roof-slate, 12 to 18 inches; 2d bench, 2"4; undermining slate, 3 inches; 3d bench, 1"10; floor slate, 6 to 24 inches; 4th bench, 4 inches; underclay. It is a bright, rich coal, with streaks of pyrites, the grain or horizontal crystallization running S. 65° E. N. 65° W., so that it is mined on the face advancing towards the N. 25° E., up the gentle rise towards the river-bluff from behind. Only the 2d and 3d benches are mined out, yielding always about 4 feet of coal. The floor rises and falls enough sometimes to exhibit the 4th bench in the gangway floor. The butts of sigillaria, from one to two feet thick, sometimes fall from the roof slate, standing vertical where they grew. Other large trunks, some of them forked, lie prostrate, crushed flat, across the gangway and rooms, in the same roof slate. The coal makes good tight gray coke, which might be mixed with raw coal for the furnace use.

Fire-clay and Shale, with ball ore 2 inches thick, 7 or 8 feet; some of it a close-grained whetstone, excellent for fire-brick, and is used to improve the quality of the fire-clay worked into fire-brick from under the Kittanning (Furnace) coal bed below.

Freeport Limestone, 5 feet thick.

Fire-clay, with balls of ore scattered through it of a very fine quality, some of them with crystallized radiated brown hematite crusts, collected from the stripping grounds over the regular ore below.

Fire-clay, without ore balls, 6 feet.

Freeport (or Summit) *Ore*, 26 feet below the coal, and running about 2 feet thick, but occasionally 4 feet (as in the Phillips hill) solid, compact, very argillaceous, almost a clay, mined by stripping, and also in gangways and rooms; mined with the pick, by bearing in on the clay above and lifting the ore in masses from 15 to 20 inches thick; yielding one and a half tons to the yard, and requiring 3 to 3¼ tons to the ton of metal; specked with delicate rose-colored specks throughout, from incipient decomposition; remarkably like the "Big-bottom" ore of the Connellsville and Uniontown region; disposed to make red short iron; requires mixture with silicious ores; would be greatly improved by mixture of ¼ magnetic or red-hematite ores. An incline plane, 210 feet high, lets down the ore from the level of the gangways and stripping-grounds to the calcining-yard below, whence it is carried off by a gravity railroad to the furnaces. A vast amount of stripping and mining has been accomplished. In some spots the bed is too thin to strip; 20 feet of stripping is the maximum it will bear. Ball ore occurs also under the regular bed. About 500 tons a week of the ore is calcined, costing 16 cents a ton. The cost of mining is about $2.15 at present, counting 2480 pounds to the ton of ore.

Fire-clay, 20 inches to 2 feet, sometimes with ball ore.

Thin-bedded Sandstones, 30 feet, forming occasionally cliffs, overhanging the river, and covering the slopes with small fragments.

Lower Freeport Coal, very variable, from 1½ to 4 feet thick.

Shale, passing down into slaty and contorted beds of—

Freeport Sandstone, thin-bedded, but forming well-marked cliffs and rough places on the hillsides; the rock that furnishes so many of those great rude contorted masses of sandrock, seen lying in profusion upon the river hills between Catfish and Sarah Furnaces, and between Brady's Bend and Red Bank. Some of its layers are solid, and 2 feet thick, rough, coarse-grained and false-bedded. The whole formation, including shale above, about 65 feet.

Coal Bed, ten inches, with two feet of fire-clay under it. Professor Owen describes this bed as being, further west, 2"6 to 3"10 inches thick, and becoming a cannel-like coal; but this does not agree with Mr. Jenning's cannel coal bed, 4 feet thick, lying 146 feet below the summit ore; for we are as yet only 100 feet below the summit ore; a very slight dip will account for the mistake. I did not myself see this small coal bed, nor do I know of any bed to correspond to it in the general system.

Interval given by Rogers as "62 feet sandstone, more or less massive, including a thin band of worthless siliceous ore." Supposing the last thin coal bed to be a member of the series properly placed, this interval will be but 45 feet, more or less.

Upper Kittanning Coal Bed, variable in thickness, disposed to cannel structure, usually thin, but in one place on the property where opened shows 4 feet of cannel, over 6 inches of bituminous coal. Rogers's section (F. R. p. 577) reverses the position of this and the coal below.

Shales, olive and blue, 35 to 40 feet.

Lower Kittanning Coal Bed, called "Furnace Bed," "Four-foot Bed," "Middle Bed," &c., in different places, yields about 3½ feet of very good coal; extensively mined above the furnaces, so that the sharp ridge between Sugar Creek and the river is well worked out; coal used raw to mix with the coke of the summit coal.

Sandstone and Sandy Shales, 30 to 35 feet, in which, on the western side of the property, and at a height of 12 or 14 feet above its base, occurs the bed of—

Siliceous Slab Ore, representing the " Buhrstone Ore " of Clarion, Venango, Armstrong, and neighboring counties of the State, on which more than 50 charcoal and stone coal blast furnaces have been running for the last two generations. It is here a solid bed somewhat less than 2 feet thick, pretty uniform in size, but variable in quality and position. When it is suspended in the sandy shales above the limestone, it is siliceous, or mixed with chert, "buhrstone," or segregated silex; but when it lies directly upon the limestone, it is a soft calcareous brown-hematite deposit, passing into ferriferous limestone, back of the furnaces, where there is not more than from 3 to 6 inches of the ore. In some places the slab ore is highly bituminous and pyritous. In other places a small coal bed or layer of bituminious slate, &c., is seen to occupy about the same position, 6 to 10 feet above the limestone. It is between this small carboniferous layer and the limestone that there always appears a shale formation, holding balls of ore. In fact the explanation of the wide extent of this buhrstone ore deposit, is simply this: first, a mud consisting largely of carbonate of iron, mixed occasionally with coaly matter, and gradually topping off with sand; afterwards, the percolation of the waters holding carbonic acid, carrying a good deal of the carbonate of iron down in an oxydized and hydrated condition, to lie upon the top of the limestone, and to penetrate the pores of its uppermost layers, partially converting them into ore. Some of the carbonate of lime was arrested in its slow descent and segregated into balls.

Ferriferous Limestone, called also the great Fossiliferous Limestone of the lower coal measures, here 15 feet thick; blue, hard, purest towards the bottom; usually crowded with encrinite joints, here showing only a few small bivalves; massive, in layers 1 to 2 feet thick, forming a quarry bench all along both sides of Sandy Creek valley above and below the furnaces, and showing the mouths of innumerable caves, connected together underground, and penetrating the ridges in all directions horizontally. This limestone fluxes the ores used in the furnaces. Some ore occurs also just under the limestone, and it will occasionally measure from 4 to 10 inches.

Blue Shales and Sandy Shales, about 30 feet. This is sometimes full of vegetable impressions.

Clarion Coal Bed, 2 to 3 feet thick in different places, a very regular and reliable bed, of good coal generally, but never becoming a large bed, and very little mined except in the northern tier of counties. It has its under clay of 2 feet.

Sandstone, more or less massive, 20 to 30 feet.

Brookville Coal Bed, very variable, both in size and quality, and of no importance on this property. At Sarah Furnace it shows four feet of very hard, dry coal, made up of alternate films or leaves of cannel, bituminous, and mineral charcoal. It is there called "the Local Bed," but it occupies exactly the place in the series belonging to the coal bed mined about Brookville and elsewhere, while here, and in many other localities, its range is marked merely by a streak of black slate.

Shale, 25 feet.

Tionista Coal Bed, here merely a foot or foot and a half of black slate and coal together, and of no value, 80 feet above the river flat on which the Rolling Mills stand.

Tionista Sandstone, 60 feet thick, and cliffing out along the water-courses, especially between the Furnaces and the Rolling Mills, according to the hardness or massiveness of its individual layers, and the accidents of the slopes. In fact, the remaining distance to the bottom of the conglomerate, representing the opening of the era of the great coal measures, is made up chiefly of sands, with occasional interludes of sandy clay beds and a few streaks of coal. The remarkable hog-back across the mouth of the valley of the Sandy, is produced by these stubborn sandrock rebels to erosion, its top being 10 feet of 2 to 4-inch plates of sandstone, cliffing out on both sides, a little false-bedded and very coarse-grained. Its lower parts are layers of 4 to 6-inch sandrock down to river level. Rogers gives under the T. S.—

Bituminous shale, interlaid with sandstone, 20 feet, and then—

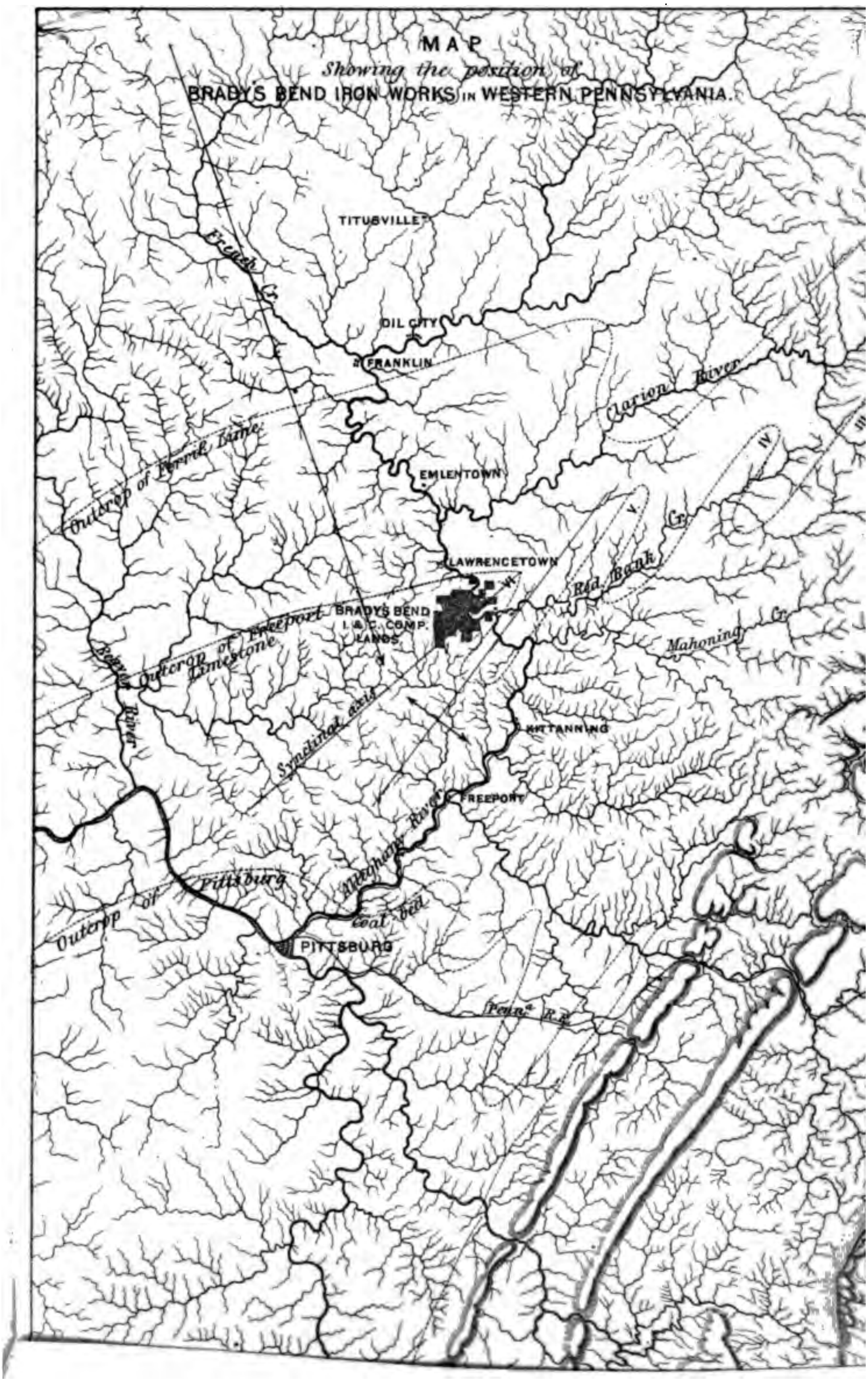
The Seral Conglomerate, in the river bed, concerning which enough has been said in the previous pages.

The accompanying section of the rocks across the Sixth Synclinal at Brady's Bend, is intended to exhibit the great horizontality of all the measures, as well as to mark the heights of the coals, ores, and limestones, and the supposed depths of the oil horizons.

The accompanying map of the property needs no explanation; but it is proper to state that it only includes those tracts which lie immediately around the Works, and were examined by me.

J. PETER LESLEY.

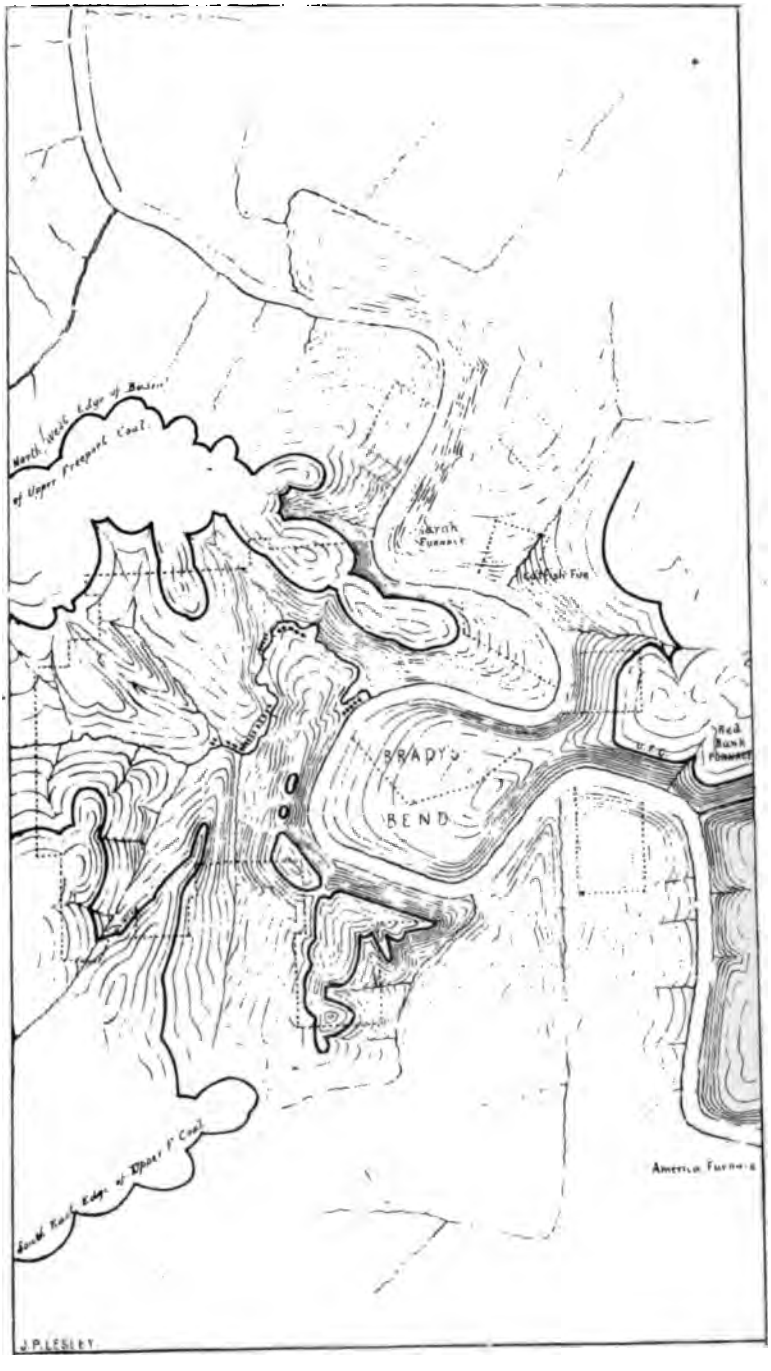
PHILADELPHIA, 1016 CLINTON STREET,
April 6th, 1865.

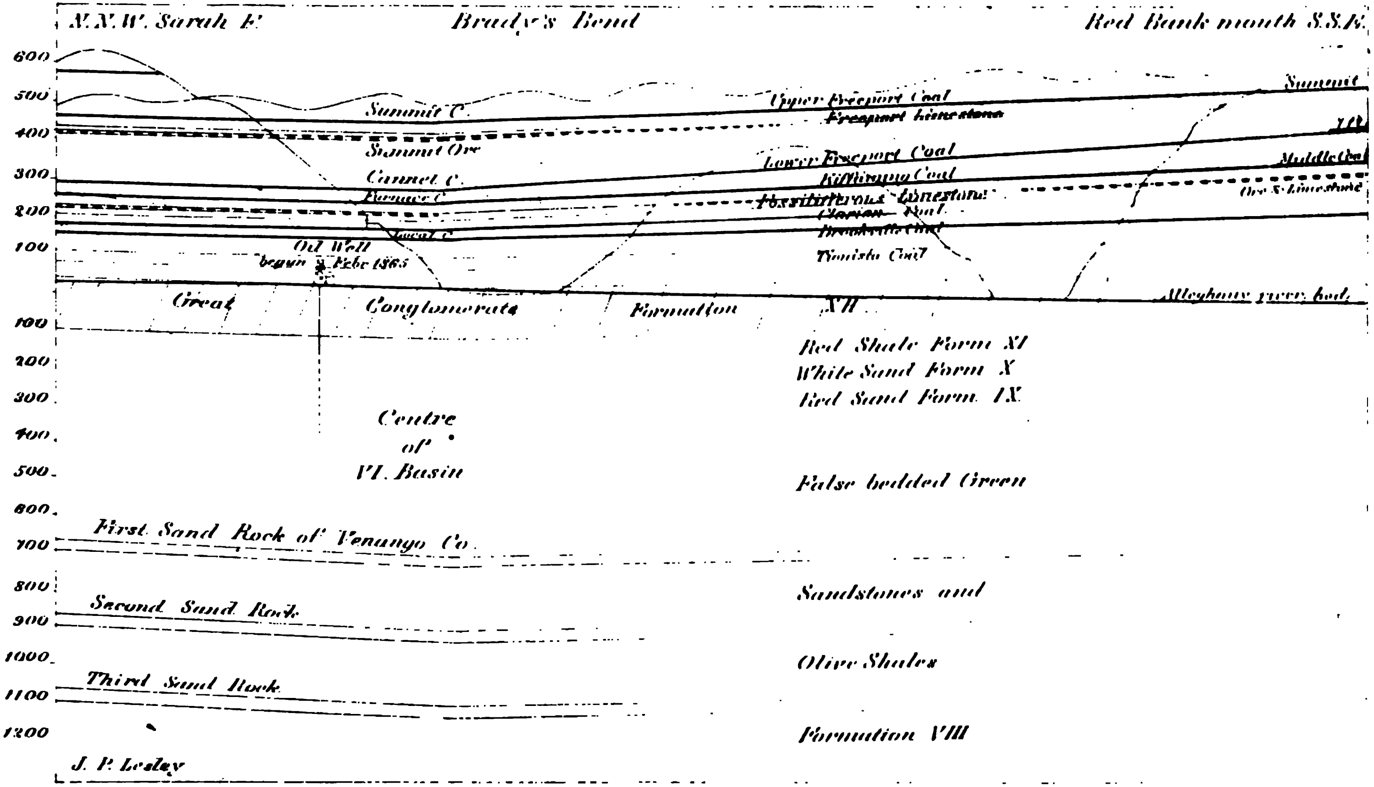


MAP

Showing the position of

BRADYS BEND IRON WORKS IN WESTERN PENNSYLVANIA.


North West Edge of Basin of Upper Freeport Coal
Sarah Furnace
Catfish Fire
BRADY'S BEND
U.F.C.
Red Bank Furnace
America Furnace
South East Edge of Upper F. Coal
J.P. LESLEY


N.N.W. Sarah F.
Brady's Bend
Red Bank mouth S.S.E.
600
500
400
300
200
100
100
200
300
400
500
600
700
800
900
1000
1100
1200
Summit C.
Summit Ore
Cannel C.
Furnace C.
Lower C.
Oil Well
begun Febr 1865
Great Conglomerate Formation
XII
Upper Freeport Coal
Freeport Limestone
Lower Freeport Coal
Kittanning Coal
Fossiliferous Limestone
Clarion Coal
Brookville Coal
Tionista Coal
Summit
XII
Middle Coal
Ore & Limestone
Allegheny river bed
Centre of VI. Basin
Red Shale Form XI
White Sand Form X
Red Sand Form IX
False bedded Green
Sandstones and
Olive Shales
Formation VIII
First Sand Rock of Venango Co.
Second Sand Rock
Third Sand Rock
J. P. Lesley

Mr. Lesley read extracts from letters respecting the discovery of oil on the Alleghany River at Brady's Bend, seventy miles above Pittsburg, and twenty miles below Franklin in Venango County, and exhibited a suite of specimens of the strata bored through, and the oil obtained.

The place of the Brady's Bend boring is shown in Plate 2 of this Volume of the Proceedings, and its relations to the Venango County Oil Sand Rocks described on pages 56, 57 above. A careful calculation, based upon observations at the locality in the spring of 1865, when the well was commenced, gave 700, 900 and 1100 feet for the respective depths of the three Venango County Oil Sand Rocks (if they extended so far as Brady's Bend) beneath the level of the river.

The depth of 700 feet was, however, reached and passed with no show of oil. The first sand rock therefore seemed to be absent beneath the Brady's Bend locality, or to be destitute of petroleum.

But at 940 feet oil was struck, and with a strong pressure of gas, January 3d, 1866. The bottles show that, from 908 to 1015, all the borings came up stained more or less with oil.

At a depth of 1015 feet the borings became clear again, and the well was stopped at 1089 feet. Seed bags at 381"6 and 425.

Pumping was resorted to and the well produced 25 barrels in 12 hours. It is now reported yielding regularly 12 barrels per day. "The crude oil will burn in a lamp as beautifully as refined oil does, and will continue to do so until the entire contents of the lamp is exhausted." (May 4th, reports 6 barrels per day.)

Whether this oil comes from the second or from the third horizon I do not know; but I suppose the latter. I judge that the oil-shows from 908 to 1015 came from the second horizon at say 900 feet, and that the present depth of 1089 feet marks with surprising accuracy the 1100 foot horizon of the Third or Great Venango Oil Bearing Sand Rock.

Having impressed upon the owners the utility of accurate records of the boring of this pioneer well, I have had the happiness to receive 61 bottles of borings, giving the appearance and condition of the strata from a depth of 142 feet (above which no record was kept) to the bottom of the well. From these bottles the following section has been prepared:

1.	Sandstone; not very coarse; rising in pieces;	yellowish; at	142 feet.
2.	" " finer,	orange,	22 to 164
3.	" " finer,	reddish orange,	4 to 168

4.	Sandy shale; in powder and pieces;	gray,	12 to 180
5.	Sand stone; very fine;	yellowish,	19 to 199
6.	Sand stone; muddy; in pieces:	yellowish,	2 to 201
7.	Sand stone; muddy; in powder:	orange,	1 to 202
8.	Shale; very fine;	bluish gray,	15 to 217
9.	Shale; very fine and powdery;	greenish gray,	9 to 226
10.	Shale (like 4 above) fine, powdery;	light bluish gray,	24 to 250
11.	Shale;	darker gray,	40 to 290
12.	Shale; fine and powdery;	more greenish than 9,	6 to 296
13.	Shale; pretty fine	yellowish greenish,	12 to 308
14.	Shale; fine and powdery;	bluish greenish,	11 to 319
15.	Shale; pieces and powder;	olive,	8 to 327
16.	Shale; all powder;	dove color,	41 to 368
17.	Shale; fine sandy (like 4) and large pieces, some powder	gray,	3 to 371
18.	Shale; (like 13) but finer; no pieces;	yellow greenish,	19 to 390
19.	Shale; (exactly like 17) but all in large pieces;	gray,	15 to 405
20.	Shale; (same as last) finer and a good deal of powder;	gray,	120 to 525
21.	Shale; (like 18) very fine;	yellow greenish,	25 to 550
22.	Shale; (like 17) smaller pieces and some powder;	gray,	5 to 555
23.	Shale; (like 17) larger pieces than 22;	gray,	10 to 565
24.	Shale; (like 10) but a little coarser and warmer;	blue gray,	25 to 590
25.	Shale; a little warmer than last and very powdery;		8 to 608
26.	Shale; (like 20 exactly) trifle finer;	cold gray,	1 to 609
27.	Shale; silicious (like last) all in pretty large pieces;	cold gray,	21 to 630
28.	Shale; muddy; (like last) a little warmer; pretty large pieces;	cold gray,	10 to 640
29.	Shale; (like last) but fine;	cold gray,	30 to 670
30.	Shale; (like 18) coarse;	warm gray,	30 to 700
31.	Shale; (like last) finer, powdery;	warmer gray,	5 to 705
32.	Shale; (not so fine as 31, nor so warm as 30);		10 to 715
33.	Shale; (like 25) fine;	cool gray,	5 to 720
34.	Shale; (like 26) fine pieces;	cold gray,	20 to 740
35.	Shale; very fine; much powder;	somewhat brickdust color,	5 to 745
36.	Shale; (almost like 3);	orange,	5 to 750
37.	Shale; (like 34) fine pieces;	cold gray,	2 to 752
38.	Shale; (like 36) powdery fine;	orange,	3 to 755
39.	Shale; (like 19) pieces;	cold gray,	12 to 767
40.	Shale; very fine;	greenish gray,	8 to 775
41.	Shale; very fine;	warmer gray,	22 to 797
42.	Shale; fine and powdery.	not quite orange,	3 to 800
43.	Shale; (like 40);	greenish gray,	20 to 820
44.	Shale; powder (containing large gray pieces);	orange,	3 to 823
45.	Shale; fine;	gray,	27 to 850
46.	Shale: all in large pieces:	blue gray,	12 to 862
47.	Shale; fine;	greenish gray,	23 to 885

48. Shale; powder holding pieces;	towards orange,	4 to 889
49. Shale; fine pieces;	greenish gray,	1 to 890
50. Shale; powder;	dark orange,	18 to 908
51. Shale; disguised with oil;	dark purple,	10 to 918
52. Shale; fine; disguised with oil;	purplish gray,	19 to 937
53. Shale; fine; " " "	dark green gray,	8 to 945
54. Shale; fine; " " "	purplish gray,	10 to 955
55. Shale; sandy; " " "	brownish green,	39 to 994
56. Shale; sandy; " " "	brownish green,	10 to 1004
57. Shale; sandy; " " "	brownish green,	9 to 1013
58. Shale; sandy; " " "	Spanish brown,	2 to 1015
59. Sandy shale; " " "	very dark green gray,	9 to 1024
60. Sand stone; soft, whitish, making a yellow sand,		41 to 1065
61. Sand stone; hard, white, making a gray powder,		24 to 1089

It will be seen by comparing the above section with that of the Sligo Salt Well, furnished by Mr. W. W. Lyon (April 7th, 1865, page 63 above), that the opinion I expressed then was correct, viz.: that the reason of the non-productiveness of the Sligo Well, and of the Clarion River region generally, was merely due to the fact that the Sligo Well, although 992 feet deep, really has penetrated the Brady's Bend strata only 800 feet, and therefore has stopped short of the third and chief oil horizon of Venango County by nearly 300 feet. I believe that, were the Sligo Well to go down this additional distance, it would yield the same petroleum and in the same quantities that the Brady's Bend Well is said to yield.

I cannot say that any accurate identification of corresponding strata in the two wells has been made out. The record of the Sligo Well is from the report of the well master, who describes the look of his borings as they are brought up in the sand pump. The record of the Brady's Bend Well is from the dried sands and powder and fragments of borings preserved in bottles. To obtain a fair comparison and identification, there is but one way, viz.: to bray the borings in a mortar and ram them into a glass tube; giving to each kind of borings as many tenths of inches of glass tube as the borer found feet of the rock; and wiping out the tube after every fresh charge, so as to keep the inner surface transparent. If this be done carefully, and the charges are well rammed down to the exact depth (marked by an ink line on a longitudinal strip of paper pasted on the outside of the tube), two tubes can be laid side by side, and any real identifiability be instantly detected. There is no reason why every well-house should not keep one or more such permanent records of its well. Some of the tubes might be half-inch, for dried and powdered borings, to show the color, and others inch tubes, for the fresh wet borings, to show the grain and fracture. As all the rocks of the Devonian system under the western coal measures are very argillaceous, it is not well to reduce to powder the borings which come from the more sandy layers, because then the prime distinction between sandstones and shales vanishes. And yet it is well to keep one record tube of powdered rocks, because the colored bands come out more plainly thus.

To make a glass-tube record perfectly useful for the study of strata, it is needful to cleanse such borings as come up disguised in color and consistency by oil. After oil is struck (however slight may be its show) all the borings from further down, for many feet and even fathoms, are stained and clotted with the oil, and should be cleansed before being charged into the tube.

Returning to the Brady's Bend Well, the glass-tube record shows belts of orange from 142 to 202; from 371 to 390; from 525 to 550; from 740 to 755; at 797; and from 890 to 908; all the intervals being filled with olive and gray shales:

Supposing the conglomerate at the river bank to be not over 50 feet thick, then the following are the probable identifications of these orange bands:

From 142 to 202 = 60 feet of red rock representing Formation XI.
From 371 to 390 = 19 " " "
From 525 to 550 = 25 " " "
From 740 to 755 = 15 " " "
From 797 to 800 = 3 " " "
From 890 to 908 = 18 " " "
} representing Formation IX; and the Red Band or Mansfield ore, of Formation VIII.

It is impossible to identify these bands more carefully, because we cannot be sure that they represent what are called red shale strata. They may represent comparatively high-colored rocks charged with nodular iron ore, and giving flows of iron rust water. This much is certain; there is no resemblance whatever between this scheme of orange bands in the B. B. Well, and the so-called red rocks in the Sligo Well section.

Plate IV will show the distance and direction from one another of these two wells, and their geographical relations to the Oil Creek region and to Pittsburg.

At the bottom of the map close to the Pennsylvania and Virginia State line will be seen the wells of Dunkard's Creek, sunk through the lower part of the Upper Coal Measures, into the upper strata of the Middle or Barren Measures, below the Pittsburg Coal; as the following record, by Mr. Robert Collyer,* of the Amber Oil Company's (now Amber Gold Mining Company) "Kener Well," on Deer

Run, a branch of Dunkard's Creek, four miles from Greensborough, county town of Greene County, will show:

"Soapstone," [meaning fire clay shale]..	25 feet.
Sandstone,	10 to 35
Coal Bed.	7 to 42
Soapstone, [fire clay, or under clay].	23 to 65
Sandstone,	6 to 71
Soapstone, 16;—and again, 19 =	35 to 106
Sandstone,	3 to 109
Soapstone and sandstone,	8 to 117
Sandstone,	4 to 121
Soapstone,	10 to 131
Sandstone, 8;—and again, 33 =	41 to 172
Soapstone,	9 to 181
Limestone,	5 to 186
Soapstone and sandstone, 12 + 17.	29 to 215
Sandstone,	19 to 234
Soapstone,	18 to 252
Sandstone and soapstone,	9 to 261
Coal Bed,	13 to 274
Sandstone, 34;—and again, 14 =	48 to 322
Limestone,	39 to 361
Sandstone,	31 to 392
Black clay,	14 to 406
Soapstone,	6 to 412
Limestone,	26 to 438
Soapstone and sandstone,	5 to 443
Soapstone, 6;—and again, 8 =	14 to 457
Limestone and soapstone,	28 to 485
Soapstone,	13 to 498
Sandstone,	4 to 502
Limestone and soapstone,	10 to 512
Soapstone and sandstone,	18 to 530
Sandstone,	99 to 629
"Leather-clay,"	23 to 652
Soapstone and leather-clay,	23 to 675
Soapstone and leather-clay,	27 to 702
Sandstone containing gold,	33 to 735
Soapstone,	23 to 758
Sandstone and soapstone,	40 to 798

the present depth of the well, April, 1866, producing no petroleum.

---

* Mr. Ben. Long, resident superintendent, lives near the well.

Supposing the 13 foot coal bed at 261–264 to be genuine (and not a false reading of some small seams of black slate), it can only represent the Pittsburg bed, with a thickness exceeding even its fine proportions at Connellsville. The limestone (322–361) will be then in its nominal place at the top of the Barren Measures; and the bottom of the well will have descended (798–274 =) 524 feet beneath the Pittsburg bed without striking either the Elk Lick or the Upper Freeport Coalbeds; showing the Barren Measures more than 500 feet thick.

The "sandstone containing gold" (702 to 735) 33 feet thick may then be the upper member of the Mahoning Sandstone; and the sandstone and soapstone (758–798) 40 feet thick may be its lower member. Perhaps a few yards further the borer would have struck the Upper Freeport Coalbed. I have seen two small fragments of gold ore, about the size of a pea and hazelnut respectively, with a button of gold, and a certified assay of similar fragments at the U. S. Mint, giving in one case over $80.00 to the *pound* of ore. These fragments were said to have come, with many others, out of this well at the depth indicated. They consisted of cubical crystals of iron pyrites sunk in translucent quartz, over which was spread irregular plates of native gold, and in the interstices of the quartz appeared galena, not in any well-formed crystal that I could find. The ore, from whatever region it came, was evidently of extraordinary richness. The well-master reports that he went through three feet of such rock, but did not recognize its value (!) and threw the fragments, with a few exceptions, into the tip heap. Two of the owners* tell me that they collected a barrel-full of this tip-stuff and had it analyzed at the U. S. Mint for gold, and it yielded $3.00 to the ton. They say moreover that the "Cowell Well" on Meadow Run (which lies between Whitely and Dunbar Creeks), say three miles to the N. or N. W. of the Kener Well, passed through the same gold-bearing sandstone at the depth of only 550 feet. Very uncertain accounts of similar strata are reported from one or two other wells in the same district.

The ease with which an infinite variety of deceptions have been played upon well-owners, company managers, and landholders, both by wandering sharpers and respectable speculators, is of itself sufficient to condemn this whole story of the discovery of gold ore in an oil well. Geologically speaking, it is, of course, an impossibility; certainly an incredibility. The outcrops of the Mahoning Sandstone along the Laurel Hill, Chestnut Ridge and Alleghany, Savage, Wills, Broad Top and other mountains, extend in the aggregate to thousands of miles; and the common constitution of the rock is so well known that none but an insane person would now look for a gold quartz pebble in it anywhere, even a hundred miles nearer to the gold-bearing belt of the Atlantic seaboard, much less here in the heart of the bituminous coal area. Nothing but an iceberg from the gold region of Eastern Canada could have deposited a collection of nuggets in Greene County, Penna. But we know the Mahoning sandstone was a shore deposit, filling in the bed of an exceedingly shallow and even-bottomed sea like Lake Erie, but many times larger, which had just before been created by the slow settling of the whole coal area a few yards under water-level; as is shown by the immense extent and regularity of the Upper Freeport Coalbed. In fact I think we must rather regard this water area as a marshy rolling prairie country submerged enough to receive about a hundred feet of sand and pebbles mixed with mud, irregularly but universally dropped into it, by the erosion of the tops of its own low hills or ridges, still standing out of water; in fact an immense archipelago of very soft rocks through which currents carried also material brought from afar. It even looks as if the parallel anticlinal mountains of Westmoreland and Fayette and Somerset Counties to the eastward were already raised and suffering erosion; and such was Dr. R. M. S. Jackson's opinion when he studied this part of the State under the direction of Prof. H. D. Rogers, chief of the State survey, in 1839.

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* Mr. Groves and Mr. S. W. Corinth, 350 N. 2d St., Philadelphia.

It is inconceivable therefore how pieces of gold-bearing quartz, iron pyrites and galena, should find a resting-place among these submerged hummocks of coal measures; much less be deposited in a stratum three feet thick. Nor can we suppose a gold-bearing vein ascending from the floor of Lower Silurian to within five hundred feet of the surface of the top of the Middle or Barren Coal Measures; for such a phenomenon is unheard of; and if such were by any chance to be struck in one well, there would be thousands of millions to one against the repetition of the accident within a radius of three miles.

When we recall therefore the discovery of a quarter keg of ten penny nails at the depth of six hundred feet in one of the wells on Two Mile Run, Venango County, and the discovery of butter of antimony in a well in Western Virginia, we may quietly wait until the Amber Gold Company sink their proposed shaft and report their first dividend from what they find.

To show the difference between the rough statement of so many yards of "soapstone," sandstone, limestone, "leather clay," and coal, made by common well-masters, or even between the record made out by careful treatment of bottled borings by an expert geologist, and the complete and accurately minute section which a well-trained civil engineer or mining superintendent has a chance to make during the sinking of a shaft, I will add an unpublished and important section of the air shaft of the Pennsylvania Railroad tunnel through the summit of the Alleghany Mountain, copied from Dr. Jackson's MS. notes of February 18th, 1858,

Clay, yellow, a little stony,	6.3		feet.
Slate, soft brown,	9.7	to	16.0
Sandstone, hard,	.4	to	16.4
Slate, bluish,	3.0	to	19.4
Sandstone, soft shelly,	11.4	to	30 8
Slate, black,	16.5	to	47.3
Sandstone, coarse, much sulphur in first inch,	1.7	to	49.0
Slate, black, with frequent S.S. strata,	20.8	to	69.8
Sandstone,	2.0	to	71.8
Slate, black,	.5	to	72.3
COAL,	.5	to	72.8
Fireclay, hard at top, soft at bottom,	11.5	to	84.3
Slate, hard, blackish,	5.0	to	89 3
Sandstone,	2.0	to	91.3
Fireclay,	9.7	to	101.0
Slate, hard,	11.8	to	112.8
Sandstone, hard,	4.0	to	116 8
Slate, black, hard,	16.4	to	133.2
Sandstone, solid,	1.0	to	134.2
Slate, black, rocky,	4.0	to	138.2
Fireclay,	7.6	to	145.8
Slate, bluish, hard,	19.4	to	165.2
Sandstone, hard,	2.0	to	167.2
Slate, black, hard, micaceous,	7.6	to	174.8
Slate, blue,	1.0	to	175.8
Slate, black, one inch at bottom soft,	5.7	to	181.5
COAL, bituminous,	5 0	to	186.5
Fireclay,	.5	to	187.0

Sandstone, brown, hard, with sulphur,	8.0 to 190.0
Slate, shelly,	1.0 to 191.0
LIMESTONE, rotten,	1.5 to 192.5
Sandstone,	1.0 to 193.5
Slate, shelly,	6.0 to 199.5
COAL,	1.0 to 200.5
Fireclay, hard,	1.0 to 201.5
Fireclay, calcareous,	1.5 to 203.0
LIMESTONE rock,	2.0 to 205.0
Fireclay, hard,	2.0 to 207.0
LIMESTONE,	1.0 to 208.0
Fireclay,	1.0 to 209.0
LIMESTONE and small seams of F. C.,	3.5 to 212.5
Slate, decomposing in air,	2.0 to 214.5
LIMESTONE,	1.0 to 215.5
Fireclay,	2.5 to 218.0
LIMESTONE,	.5 to 218 5
Slate and fireclay,	11.0 to 229.5

which cannot be many feet above the Great Bed cut by the tunnel in its upward grade of 1° westward, the bed itself descending with a dip of 1° westward. The above 229.5 therefore represents the middle portion of the Lower Coal Measures. The entire absence of workable coal beds above the tunnel bed is due to the fact, that the top of the section is not high enough to take in the Freeport Series, which underlie the Mahoning Sandstone.

Pleasant Unity is a village nine miles south-southwest from Latrobe, on Sewickley Creek. West-northwest of this village two and a half miles is Pauf Graff's oil well, begun October, 1864, which commences 50 feet beneath the Pittsburg Coal-bed, and reached a depth of 550 feet in May, 1865, in a mass of sandrock. It reported "shows of oil at 450, 510, and 550; and pumped at each, getting several gallons."

Three hundred yards due north of this well, is the Old Oneida Salt Well, bored in 1840, 800 feet deep, a tradition being in existence that it flowed a hundred barrels of oil per day. On the strength of this tradition it was reamed out in 1858, with no result beyond passing a show of oil at 538 feet, and after that coming (at a depth not stated) to a coal-bed from 12 to 14 feet thick; which, if not fabulous, must be an exaggerated estimate of the Upper Freeport Coal-bed, the outcrop of which is not three miles away, at the foot of the Chestnut Ridge. It is probably the 7 feet coal-bed of the following section, and a good illustration of the unreliability of the thickness of coal-beds in oil well records. The interesting point of this section is the limitation of the Barren Measures to about 50 + 538 + ? = say 600 feet.

The following is a record of 844 feet of St. Mary's Well, on Sewickley Creek, about a mile from Chestnut Ridge, in Mt. Pleasant Township, Westmoreland County, Pennsylvania, furnished by Mr. S. S. Jack, of Pleasant Unity.

Mouth of well, geologically, about 50 feet below Pittsburg Coal-bed; and a quarter mile east of its outcrop.

Slate rock,	40 feet.
Reddish rock,	12 to 52
Soapstone,	10 to 62
Hard rock,	12 to 74
Soft rock (water crevice at 86 feet),	12 to 86
Reddish rock,	14 to 100
Hard blue rock,	70 to 170
Block slate or shale; (1st oil-show at 184),	14 to 184
First sand rock, hard, white,	96 to 280
(Very large water vein at 280.)	
Gray rock (2d oil show and gas at 427),	147 to 427
Black rock,	46 to 473
Limestone,	70 to 543
Second sand rock,	15 to 558
Horseback,	7 to 565
Coal-bed [Elk Lick coal?],	7 to 572
Third sand rock, white,	30 to 602
Hard gray rock [Mahoning S. S.?],	65 to 667
Coal-bed [Upper Freeport?],	2 to 669
Fourth sand rock, white,	30 to 699
Dark rock,	16 to 715
Soapstone,	16 to 731
Fifth sand rock, white,	24 to 755
Limestone [Freeport],	23 to 778
(Salt water crevice at 778, gas very strong.)	
Sand rock, very hard,	66 to 844

The rest of the record of this well is not at present obtainable. Mr. Jack was good enough to forward 14 samples of both rock and coal; adding: "We expected to find a small bed of coal within the first hundred feet; but it was not noticed; although found in a well bored a short distance, say 70 rods, southwest; and also in gigging for water 14 feet under the surface, at a point a quarter of a mile to the south."

There is always at least one small bed of coal near the top of the Barren Measures, under the Pittsburg bed.

"There is a great flow of water and gas from the well, the gas acting periodically with force sufficient to eject the water from the mouth of the tubing (laid horizontally 6 feet from the ground) to a distance of 50 feet." The strong dip from the anticlinal of the Chestnut Ridge makes all the wells along its western foot artesian. "This well has never been properly tested for salt or oil, because the fresh water has never been exhausted."

The following is the record of Governor Johnson's oil well, bored in the centre of the gorge of the Loyalhanna River through Chestnut Ridge, about six miles east of Latrobe. The mountain rises 800 or 900 feet above the bed of the river, and is capped with the bottom coal measures. The well commences at a point about thirty rods up stream from where the axis of the great anticlinal of the Ridge crosses the river. It is therefore nearly on the crown of the arch. White and red sandrocks belonging to the Upper Devonian system (IX and X) form crags overhanging the river banks.

"Soil,"		14	feet.
Slate, blue, to a vein of fresh water,		25	to 39
"Bluestone,"		25	to 64
Soapstone,		4	to 68
Bluestone,		10	to 78
Sandstone,	white to salt water vein,	24	to 102
	gray to where "tools dropped, ten inches,"	22	to 124
	"black,"	30	to 154
small show of gas, borings of black slate, perhaps coal; water-vein white as milk.			
Black slate, pretty soft,		60	to 214
"Bastard blue stone,"		26	to 240
Sandstone,	white to a grand spring of fresh sulphur water,	74	to 314
	pebble rock,	2	to 316
	quartz rock,	45	to 361
	white,	43	to 404
Black slate,		*18	to 422
Sandstone; to a vein of gas,		10	to 432

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* Omitted, and perhaps justly, in S. M. Wickersham's letter, No. 124 First St., Pittsburg, June 14th, 1865.

Soapstone,		75 to 507
Blue slate,		35 to 542
Blue stone,		15 to 557
Gray stone,		35 to 592
Brown, very hard, red in centre, the rest blue,		43 to 635
Sandstone,	red; with blue stone; salty,	*68 to 703
	gray,	10 to 713
	red; with blue stone,	20 to 733
	blue; salty,	22 to 755

the depth of the well July 20th, 1865, when the manager wrote, "We have lots of gas and soot, and the rock is very oily and salty."

Record of Borings on the Clarion Coal and Oil Company's tract, Wilcox, Elk County, Pa., sunk by Adams & Babcock, communicated by Mr. O. N. Adams. The well is situated on West Branch of Clarion (West Toby), on Warrant No. 2676, near and inside of the south line of McKean County, Pennsylvania.

"Coal crops out about 370 feet above well mouth, in the surrounding hills."

Conducting pipe through gravel,		41	feet.
Slate; (at 60 feet from surface heavy water-course,)		30 to	71
Shale; red,		137 to	208
Sandstone; blue,		8 to	216
Slate;	"These red shales are hard and compact like sandstone."	26 to	242
Shale; red,		64 to	306
Sandstone; micaceous,		21 to	327
Sandstone; blue,		5 to	332
Shale; *red*,		31 to	363
Slate,		13 to	376
Sand; blue,		8 to	384
Shales; *red* (salt water),		31 to	415
Sandstone; blue,		14 to	429
Slate,		85 to	514
Sandstone; micaceous,	("mica and iron pyrites abundant,")	47 to	561
Slate, ("often called black sand,")		77 to	638
Sandstone; blue,		20 to	658
Slate,		43 to	701
Sandstone; micaceous,	(gas and black soot abundant for 100 feet downward,)	48 to	749

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* 100 feet in S. W. Wickersham's letter of July 22d, 1865.

Shales; olive,		65 to 814
Sandstone; micaceous,		21 to 835
Shales; olive; very soft; "putty rock,"		11 to 846
Sandstone; micaceous,		18 to 864
Shales; olive,		7 to 871
Sandstone; micaceous,		5 to 876
Shales; olive,		5 to 881
Sandstone; micaceous; chocolate hue,		9 to 890
Shales; olive; black gas from here downward,		23 to 913
Sandstone; micaceous,		6 to 919
Shales; olive,	six inches of sandrock interposed between 6 and 6,	6 to 925
Shales; *red*,		6 to 931
Sandstone; micaceous; very hard; olive,		5 to 936
Shales; olive,		2 to 938
Sandstone; micaceous; silicious; hard; compact,		10 to 948
Shales; olive,		6 to 954
Shales; *red* and olive,		2 to 956
Shales; olive,		38 to 994
Sandstone; gray; light; very hard; iron pyrites,		3 to 997
Shales; very soft,	a few inches of hard sand rock interposed between these.	6 to 1003
Clay; blue,		6 to 1009
Shale; olive; more compact; 3 divides,		65 to 1074
Sandstones; micaceous; dark soft,	(strong smell in derrick lifting tools,)	36 to 1110
Soapstone or mud vein,		2 to 1112
Sandstone; gray; very hard,		1114
Sandstone; light gray; very hard,		1116
Sandrock; bottom very hard and very fine,		28 to 1140
Slate rock; very hard with quartz intermixed,		25 to 1165
Sandstone; very hard; fine; soft in streaks; at 1172 feet occurs mud and soft spot 4 inches; here a gas vein spouted five times twenty feet high; and again, but not so strong, at 1202 feet, March 27th,		36 to 1201
Sandstone; very hard; fine; soft in streaks,		26 to 1227
Slate rock with scales of hard sand,		10 to 1237
Slate rock; gas in sand-pump,		11 to 1248
Sandstone hard, and slate soft; black soot and smell on tools, April 6th,		21 to 1269
Slate with sand; red and white; very small pebbles, April 13th,		25 to 1294
Slates with sand,		8 to 1302

Record of No. 2 well on Hyner Run, half a mile above its junction with Pithole Creek, Venango County, Pa., furnished through the kindness of General Tyndall, of Philadelphia.

Length of conductor to solid rock,	9 feet.
Soapstone,	
Sandrock, hard white; layers of gray; large water-course,	71 to 80
Slate,	48 to 128
Sandrock ("2d"), about	4 to 132
Slate,	68 to 200
Sandrock; about	5 to 205
Soft slate,	4 to 209
Sandrock; hard and then with	6 to 215
Hard and soft streaks,	24 to 239
Slate,	220 to 459
White sandrock,	31 to 490
Slate,	50 to 540
Sandrock ("4th"),	16 to 556
Crevice, "with a very good show of oil and gas,"	2 to 558
Sandrock,	3 to 561
Slate,	39 to 600
Reddish slate in thin layers and hard sand rock gradually becoming soft with a fine show of oil and some gas,	12 to 612
Slate; hard to the bottom,	22 to 634

The well at this depth pumped 50 to 75 barrels of oil per day for some months.

Record of the Old United States Well (Frazier Well) on Pithole, Venango County, Pa.

Slates; variegated,	95 feet.
1st Sandrock,	40 to 135
Slates; variegated,	215 to 350
2d Sandrock,	30 to 380
Slates; variegated,	85 to 465
3d Sandrock,	20 to 485
Slates; variegated,	110 to 595
4th Sandrock; to bottom,	12 to 607

This well is said to have yielded originally 300 barrels, and now to yield from 20 to 100 barrels per day, according to different authorities.

The record of No. 47, or Burchell Well, which is said to flow 150 to 200 barrels per day, does not vary over two or three feet in the tops and bottoms of its sandrocks, from the record of the Frazier Well, given above.

Record of Glade Well, or Well No. 7, Sugar Camp branch of Stewart's Run (half mile up the branch), two miles from Alleghany River, and about the same distance east of Pithole. Stewart's Run is in the next valley east of Pithole, descending southward to the River, Venango County, Pa.

Slate and crevice of water,	50 feet.
Slate (common),	20 to 70
Sandstone; hard, and gas,	5 to 75
Slate,	20 to 95
Sandstone and gas,	2 to 97
Soapstone,	21 to 118
Soft clay slate,	78 to 196
Red slate,	50 to 246
Soapstone slate,	20 to 266
Red slate and water crevice,	21 to 287
Red slate,	31 to 318
Sandstone; white, and gas,	37 to 355
Slate,	40 to 395
Sandstone and slate,	12 to 407
Sandstone; hard, and gas,	25 to 432
Slate; mud vein,	20 to 452
Slate and sandstone,	15 to 467
Sandstone; hard; white,	10 to 477
Sandstone; gray, and gas,	10 to 487
Slate (common),	53 to 540
Sandrock; coarse,	4 to 544
Soapstone and water crevice,	20 to 564
Sandstone; gray,	8 to 572
Slate,	10 to 582
Flintrock,	2 to 584
Sandstone with crevices,	4 to 588
Slate,	10 to 598
Sandstone,	2 to 600
Slate,	12 to 612
Sandstone and red slate,	4 to 616
Slate; to bottom,	15 to 631

Actual depth of well when abandoned 610 feet, the discrepancy being left unexplained.

Mr. Lea exhibited specimens of Eozoon Canadense, received from Mr. Billings, of Montreal, in rough, polished and dissected states. A discussion ensued, in which Prof. Hayden, Dr. Le Conte, Mr. Barnes, Judge Hare, and Mr. Lesley took part.

Pending nominations Nos. 541, 547, 548, 549, were read and balloted for, and there being no further business, the presiding officer announced the following persons duly elected members of the Society.

Dr. Pliny Earle, of Northampton, Massachusetts.

Dr. Owen Jones Wister, of Germantown, Pennsylvania.

Mr. Thomas Davidson, of Brighton, England.

Dr. Fridolin Sandberger, of Wurtzburg, Bavaria.

And the Society was adjourned.

Stated Meeting, May 4, 1866.

Present, sixteen members.

Vice-President Prof. Cresson, in the Chair.

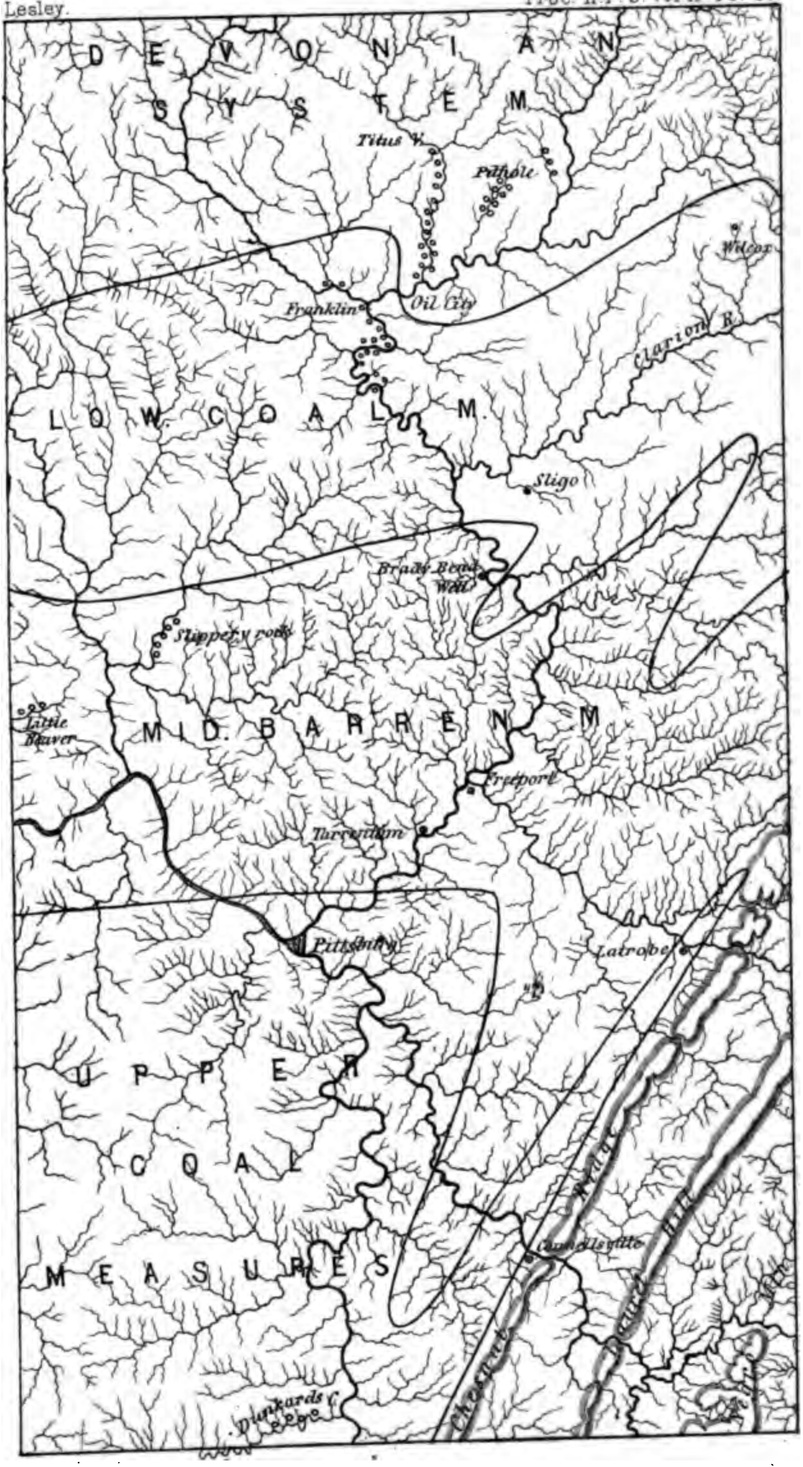
A letter accepting membership was received from Dr. O. J. Wister, dated Germantown, April 25th.

A letter from Mr. J. R. Snowden, Secretary of the Historical Society of Pennsylvania, requesting facilities for Mr. Edw. Armstrong to examine sources of information on the subject of the life of the late Mr. Duponceau, was read, and on motion of Dr. Wood the request was granted.

A letter respecting the publication of a treatise upon the laws of the French Language was received from Prof. E. Taliaferro, dated College of William and Mary, Williamsburg, Va., April 25th.

A photograph of Prof. S. S. Haldeman was presented by Dr. Le Conte, for the Album.

Donations for the Library were received from Sig. Lombardini, Dr. Schinz, the Bureau of Mines, the Royal Astronomical Society, the Rhode Island Society for the Encouragement of Domestic Industry, Dr. B. A. Gould, Prof. W. A. Norton, Lesley. Proc. A.P.S. Vol X. Pl. IV.



A Record of Fourteen Oil Wells at Brady's Bend, Armstrong County, Pennsylvania.

By. J. P. Lesley.

(*Read before the American Philosophical Society, Phila., Nov. 1st,* 1872.)

Having recently requested Mr. Persifor Frazer, Assistant Professor of Chemistry in the University of Pennsylvania, to examine for new estimates of quantity the coal areas which have escaped erosion, in the country on the two sides of and closely adjoining the Allegheny River, at the remarkable ox-bow bend in its course, 70 miles above Pittsburgh and 60 miles below Oil City ; he brought back with him a MSS. report of of the wells bored by the company on the river banks and along the beds of the ravines descending to it from the west. We owe this report to the kindness of Stephen Halbrook, Esq., Superintendent of the Brady's Bend Iron Works.

It is needless to recapitulate the history of the oil discoveries, and the gradual extension of the oil producing districts from Titusville and the line of Oil Creek eastward to the Tidioute district, southeastward to the Clarion, westward to French Creek, and southward via Oil City, Franklin, Parker's Landing, and Brady's Bend, to the neighborhood of Butler, where the last discovery excitement is now raging. It is only necessary to refer to my report on the geological grounds for believing the middle Allegheny River districts to be productive oil country, published in the Proceedings of this Society, in 1865.* In that paper I have sufficiently described the *locale* of the wells now to be described. These records may also be compared with similar records communicated to the Society and published in its Proceedings of April, 1865.

The "Engineers' Datum" of the following table is an assumed level, *one hundred feet lower* than a mark made on the Brady's Bend Iron Company's warehouse, on the river bank, showing the extreme height reached by the great and disastrous freshet of March 17, 1865.

No.	Height of well mouth above Eng. datum.	Depth of well.	Depth below river, highest water mark.	First yield in barrels per day.	Present yield per day.
1..	96 feet.	?	?	?	1 bbl.
2..	232	1,400	1,268		*no sand rock.*
3..	97.62	1,111	1,113	5 ; bbls.	1 bbl.
4..	97.69	1,262	1,264		*abandoned.*
5..	100.31	1;105	1,105	7 bbls.	2 bbls.
6..	300.48	1,290	1,090	5½ bbls.	4 bbls.
7..	437-41	1,414	1,077	9 bbls.	8 bbls.
8..	379.18	1,345	1,066	840 bbls.	150 to 200 bbls.
9..	101.38	1,065	1,066	4½ bbls.	3-4 bbls.
10..	330.27	1,300	1,070	1 bbl.	*abandoned.*
11..	111.13	1,200	1,189		*powerful gas blow.*
12..	216.50	1,212	1,095½	12 bbls.	13 bbls.
13..	426.38	1,402	1,076	3 bbls.	2 bbls.
14..	359.89	?			*to be sunk to 4th sand.*

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* See Proc. A. P. S., vol. 10, p. 61.

From the above table, it appears that all the oil-producing wells mentioned in it get their supply from one stratum lying in an undisturbed and horizontal position, varying in their actual depths below a fixed datum level from 1,113 to 1,066 feet, a difference of only 40 feet. This difference is due to three causes, viz. :—1. The different depths in the oil-bearing stratum penetrated by the bottom boring of the wells; 2. The slight inequalities in the upper surface of the stratum ; 3. And chiefly, to a general slight dip of the rocks, both from the northwest and from the southeast, in towards the centre line or axis of the trough or basin which here crosses the Allegheny River in its northeast-southwest course ; and also to a still slighter and almost insensible decline of the axis of the basin itself southwestward.

The table also confirms what was proven years ago, long before the fact was acknowledged by oil men, namely, that it makes no difference whether a well is started in the valley bottom or on the hill tops, provided it goes down to the uniform and nearly horizontal oil-bearing sandrock. For some of these wells have their mouths at elevations more than 300 feet greater than others. Some on the river bank, and others high up at the heads of side ravines. The great No. 8 well was commenced at an elevation (379—96=) 283 feet higher than those on the river bank which yield only from one to three barrels a day.

The following table shows the thickness of the third sandrock where it was passed entirely through :

No. 2.—No sandrock found and no oil.

No. 4.—Sandrock, 26 feet ; hard fine white sand.

No. 5.—Sandrock, 27 feet ; fine pebbles.

No. 6.—Sandrock, 16 feet ; with slate partings.

No. 7.—Sandrock, 27 feet ; pebbles pretty coarse.

No. 8.—Sandrock, very coarse and open.

No. 9.—Sandrock, pebble very fine and close, very little gas.

No. 10.—Sandrock, 10 feet ; pebbles pretty fine, except in one thin streak.

No. 11.—No sandrock, no oil, but great gas blow, doubtless from a fissure.

No. 12.—Sandrock, 17 feet, all pebbles ; steady flow of oil.

No. 13.—Sandrock, 13 feet ; coarse open pebbles ; and a fair amount of gas.

No. 14.—Sandreck, 13 feet ; large coarse pebbles ; fair amount of gas. Other noteworthy facts are as follows :

No. 1 well, on the river bank, one half mile above the rolling mill, begun March, 1865, finished 1866.

No. 2 well, at the mouth of Cove Run, May, 1866—June, 1870.

No. 3 well, on the river above the mill, commenced August, 1868—pumping in September, 1872, 1 barrel a day.

No. 4 well, on the river above the mill, May, 1869—March, 1870. Cost $10,405. Record of strata given below.

No. 5 well, on the river above the mill, June, 1869 April, 1870. At 931 feet struck so powerful a gas vein, that the bore-hole was deluged with water and abandoned for four months. In June, 1871, a three quart nitro-glycerine torpedo was exploded without increasing the production of oil. The pebble rock was almost as fine as sea-sand.

No. 6 well, on Queenstown Run; August, 1870—April 5, 1871; drilled with the water cased out; all the previous wells were drilled in water; casing commenced at 357 feet; not much gas.

No. 7 well, on Queenstown Run; August 7, 1870—March 1, 1871; water cased out at 512 feet; some gas at 1,050; commenced pumping about 9 barrels a day, and has produced up to September 7, 1872, 4,133 barrels.

No. 8 well, on Queenstown Run; June 26, 1871—September 22, 1871; water cased out; first show of oil September 22, and began to fill up very slowly. At 12.35 A. M., September 23, struck a vein of gas and oil which spouted over the top of the derrick, and was fired by the night lamp hung in the derrick, burning the rigging down. The spouts occured every two minutes. At 9 A. m. the fire was extinguished and the oil began to fill the tank at the rate of 35 barrels an hour, but gradually calmed down to about 60 barrels a day during the first month, and October 22 ceased to flow. Tubeing and sucker rods were then put in, and she began to flow again at the rate of 150 barrels a day.

This well has been cleaned out many times to keep her in good running order. Immediately after any one such cleaning she produces from 70 to 90 barrels a day, and gradually falls off to about 20 to 25, when it is understood that she again needs cleaning. In fifty weeks she has produced 9,505 barrels. There is not much gas except when flowing.

No. 9 well, on the river opposite Catfish; June 24, 1871—October 24, 1871; water cased out; cost $5,750.

No. 10 well, on Lower Campbell Tract; July 10, 1871—May 22, 1872; water cased out. After passing through third sand at 1,300 feet, put in a 4 quart torpedo, which seemed to have very little effect. Sand pumped for two days afterwards and found that she filled up with less than a barrel of oil per day, and therefore concluded it was useless to tube her. Not much gas at any time.

No. 11 well, on river half mile below the mill; August 24, 1871—June 24, 1872; water cased out at 437 feet, Struck very heavy vein of gas at 858 feet.

The gas from this well, by calculation, would supply fuel to run the rolling mill and machine shop boilers, being therefore equal to 100 tons of coal per week.

The pressure of gas would sometimes lift the tools 20 or 30 feet in the hole, tools weighing 1,700 pounds and rope 300 pounds. The flow of gas is enormous and continuous.

No. 12 well, on Queenstown Run; December 9, 1871—April 12, 1872; water cased out at 394 feet. Struck heavy vein of gas February 2, at

725 feet, which caused a flow of water until March 1, when casing was put in and the water stopped off.

Struck oil at the top of third sand April 4, at 1,183 feet, the rock being nearly all good pebble rock; after passing through it (1,200 feet) drilled 12 feet into slate for a pocket; tubed well April 12; commenced pumping 12 barrels a day, and the well is now doing 13 barrels. Much gas all the time. Cost $6,557.

No. 13 well, on Queenstown Run; January 2, 1872—May 8, 1872; water cased out at 290 feet. Best show of oil at 1,390. Cost $6,671.

No. 14 well, on Queenstown Run; June 11, 1872—September 2, 1872; water cased out at 227 feet. Little oil in third sand; will push it deeper.

It only remains to give vertical sections of the Measures passed through, premising, that the Great Conglomerate No. XII, the base rock of the Coal Measures forms the low cliffs at water level in the river valley; all the hills being built up of the nearly horizontal Lower Coal Measures or Allegheny River System, and the underground of Sub-Carboniferous and Devonian.

The following records of wells No. 4 and No. 5 of the foregoing description were made from labels on sample bottles, marked daily by the well drillers, and are not supposed to be perfectly reliable, but are nevertheless for the most part accurate notations of the character of the Sub-carboniferous and Upper Devonian Measures penetrated in reaching the oil-bearing strata.

RECORD OF OIL WELL NO. 4.

Struck the "mountain sandrock" at a depth of 50 feet.

Got through it at	240	feet.
Grey sand at	898	"
Grey sand at	933	"
Grey sand at	940	"
Dark gray sand	944	"
Black slate	947	"
Dark rock	952	"
Dark rock	955	"
Gray sand	965	"
Slate rock	976	"
Black rock	992	"
Black sand	998	"
Grey sand	1,008	"
Grey sand	1,003	"
Blue sand, hard	1,005	"
Black sand, hard	1,008	"
Blue sand, pretty hard	1,012	"
Slate rock	1,015	"
Hard sand	1,038	"
Sand	1,085	"

Sandrock	1,100	feet.
Red sandstone	1,126	"
Black sand	1,140	"
Grey sand	1,141	"
Grey sand	1,143	"
Mud	1,144	"
Blue slate	1,145	"
Soft slate	1,146	"
Soft slate	1,147	"
Shelly	1,148	"
Slate	1,150	"
Slate rock	1,152	"
"	1,162	"
"	1,165	"
Shelly rock	1,172	"
Slate rock	1,176	"
"	1,181	"
"	1,183	"
"	1,191	"
Blue slate	1,194	"
"	1,197	"
Shelly rock	1,211	"
Traces of oil	1,220	"
Slate	1,235	"
Slate rock	1,248	"
Dark slate	1,252	"
Slate—well abandoned at	1,260	"

RECORD OF WELL NO. 5.

Struck the mountain sandrock at	45	feet.
Got through it at	215	"
Grey sand	350	"
Slate rock	400	"
"	440	"
Soft slate rock	460	"
Grey rock	490	"
Slate rock	510	"
Slate shells	530	"
Slate rock	560	"
"	580	"
"	620	"
Shell rock	640	"
Slate rock	660	"
"	670	"
"	690	"
"	710	"

Sandrock	715	feet.
“	720	“
“	730	“
Slate rock	745	“
Red rock	750	“
Pebble rock	775	“
Sandrock	779	“
“	780	“
“	790	“
Slate rock	795	“
Sandrock	805	“
Red rock—		
Grey sand	808	“
Sandrock	812	“
“	815	“
“	820	“
“	822	“
“	824	“
“	826	“
Red rock—		
White sand	825	“
Rock	830	“
“	840	“
Grey sand	844	“
“	847	“
“	848	“
Sandrock	850	“
Blue rock	855	“
Sandrock	860	“
Black sand	865	“
Sandrock	896	“
“	930	“
Red rock—		
Sandrock	939	“
“	940	“
“	941	“
“	943	“
Shelly rock	948	“
“	951	“
“	954	“
Slate Rock	965	“
Red rock	972	“
Hard sand	986	“
Soft sand	998	“
Dark rock	1,018	“
Red sandrock	1,026	“

Slate	1,050 feet.
Shelly rock	1,055 "
THIRD SAND rock	1,073 "
Sandrock	1,076 "
"	1,078 "
Slate and shelly	1,084 "
Pebble rock	1,085 "
"	1,090 "
Sandrock	1,092 "
" Tubed well	1,100 "

and began pumping about 7 barrels in 24 hours.

It is a pity that the above records are so defective. The intervals between the numbers given are in many cases large and not noted, and must not be taken as the *thicknesses* of the rocks named.

There is, however, a positive value in all such records, however defective, as may be noted by the recurrence of the *red rocks* in the above lists. These may define the position of the great red formation of the Palæozoic series No. IX of the Pennsylvania State Survey, the representative of the Old Red Sandstone of English geologists, and the Catskill Formation of the New York geologists.

In Well No. 4 it is noted once only as being struck at 1,126 feet.

In Well No. 5 it appears at 750, 805, 826, 930, 972 and 1,026 feet.

The thickness of the Conglomerate No. XII is accurately determined in Well 4 at 190 feet, and in Well 5 at 170 feet.

The thickness of the Conglomerate No. XII in the salt well 45 miles further down the river, as determined (not with entire accuracy) from the Record, published on p. 65, vol. X., of the Proceedings A. P. S., April 1865, is 494½ — 334½ = 160 feet; or, if the top of XII be placed at the "White Sand" 440½ and all the "Gray Sandrocks" be included down to 666''11, = 220 feet.

At Sligo Furnace on the Clarion (p. 63, vol. X.), the Conglomerate No. XII, seems to be only 117 feet thick, soft red slate of XI under it only 3 feet thick, and the red and blue slates of IX lie 786—183 = 603 feet below its base, or 720 feet below its top.

The resemblance of this to the record of Well No. 5, given above, is very observable. Thus, in Well No. 5, the red rocks of IX are first struck at 750—45 = 715 feet beneath the top of the Conglomerate.

In the Sligo Well (15 or 20 miles to the northeast of it), the top of the red rocks is 786—66 = 720 feet beneath the top of the Conglomerate.

In the Well No. 5, the redrocks are noticed at intervals from 750 to 1026 = 276 feet.

In the Sligo Well, the red rocks occupy an interval of only 118 feet.

It must be taken into consideration, however, that the lowest red rocks of the well No. 5 may represent not No. IX, but the Red Beds of VIII, described in my report to Professor H. D. Rodgers, in 1841, and published in his Final Report of the Geology of Pennsylvania, under the head of the Geology of the Wellsborough Valley or Tioga River District in Tioga County. To trace the thinning away of these calciferous and ferriferous red beds of VIII (Lower Divonian) on their way towards Ohio, underground, is one of the desiderata of American geology.

Other well-boring records are published on pages 227 ff, vol. X, Proc. A. P. S., but most of them are confined to the Coal Measures. Those on p. 238 ff, however, penetrate the Devonians to considerable depths and show the red rocks in positions analogous to those described above.

In one well, at the head-waters of the Clarion, the mouth of the well being 370 feet below a coal bed, and also below the bottom of XII, the red rocks of IX (?) occur from 216 to 415 — an interval of 200 feet, which is about the normal thickness of IX in this zone of its decresence westward. The Manchester (Tioga river) red beds (?) were struck at intervals from 925 to 956 — 41 feet, *i. e.*, with an interval of 510 between their top and the bottom of IX.

In the Glade Well near Pithole (page 241, vol. X), in the Oil Creek country, the red slates were first struck at 196 and got through at 318, the interval being 122 feet. Some red shale was then struck near the well bottom (abandoned, no oil) at 612, *i. e.*, 294 feet below the bottom of the upper red shales.

These also probably represent IX and the Manchester red beds, with a diminished interval due to westing.

These red rocks correspond to the Marshall group of Michigan, of Winchell (Proc. A. P. S., vol. XI., p. 74), the Gritstone redrocks above and the Chocolate shales below (the latter just over the Hamilton) in Ohio (Idem, p. 75), and to the Brown shales of the Keokuk group of Indiana. They are very noticeable to the traveller on the railways crossing Northern Ohio.

NOTE.—I have received the following letter of explanation respecting the wells at Brady's Bend :

ST. LOUIS, MO., *November* 13, 1872.

Dear Sir :—The detailed surveys were begun and mostly made under my direction, and the wells Nos. 6, 7, 8 and 9 were located by me. This would be of no interest to you or the public were it not that the location of these wells was the result of a long, carefully pursued, and at least apparently successful investigation into the laws of the distribution of the oil in the "sandrocks."

You had already shown that these rocks existed there and at what depth, and had also shown that the general stratography of the district rendered it reasonably certain that oil would be found there, and this had been confirmed by the results of boring in the case of two of the five wells sunk.

I tried to find the law of distribution in its application to narrower limits, so as to decrease to the utmost the risks, and increase to the utmost the chances in sinking wells.

Of the five sunk before I went there, two were productive; of the four sunk since I left, one is productive; of the four I located, namely, Nos.

6, 7, 8 and 9, all are productive. No. 9, which is the least productive of the four, was located under restriction to the Lower Campbell tract. No. 8, the most productive, was the last one I located without restriction. Nos. 6 and 7 were both down before any other well was started in the Whiskey Run or Queenstown Run field. The same principles which guided the locating these wells, led me to advise the Brady's Bend Iron Company against trying the Upper Campbell tract, and the results of boring there by other parties have confirmed their correctness, and there have been so many confirmations that my confidence in the principles amounts to conviction.

In opening the Whiskey Run or Queenstown Run field, I simply followed the general line of strike from the Armstrong Run field; but in locating individual wells I sought lines and areas of deposition of coarse pebbles in the "sandrocks" out of broken condition of the "sandrocks."

I had not so far completed the research into the laws which govern the direction and position of these lines and areas that I felt free to communicate them when I left the oil country, but hope to push the investigations further hereafter. Meanwhile it may be of some interest that the above results have followed an effort pursued by scientific methods to find and apply such laws.

Yours, very respectfully,

JAMES E. MILLS,

Vice President Big Muddy Iron Company.

PETROLEUM.

PROCEEDINGS AMER. PHIL. SOC.

MAY, 1865.

J. P. LESLEY.

Mr. Lesley took occasion, in presenting this communication of Mr. Sheafer, to describe the method of the existence of the petroleum in the eastern coal-field of Kentucky, which he had lately visited.

The whole surface of that part of the State of Kentucky, watered by Paint Lick Creek and its tributaries, is a mass of hogback ridges, sharp conical hilltops, and profound rock gorges with steep or vertical walls, bordered by a broken highland of coal measures. The highest hilltops of which are about 700 feet above the beds of the deepest gorges, or cañons.

The wildest and most beautiful scenery meets the eye at every turn; long walls of rock, with their edges against the sky; extraordinary piles of pulpit-rocks, standing isolated at the junction of two streams; overhanging tablets of sandstone, two hundred feet long, and thirty feet thick, projecting twenty feet beyond their supporting cliffs, and a hundred and fifty feet above the spectator's head; dark forest gorges, heading up in caves, over the roofs of which fall high cascades; and in the decomposable faces of the cliffs, bear-dens, and robber-caverns, and pit-holes of all sizes, sometimes so numerous as to give the traveller the impression that he might make out old inscriptions, with a genuine meaning in them, if he tried.

From the disintegration of this world of friable sandrock, from the slow cutting of the waters of all the forks of Paint, down through from 200 to 250 feet of such strata, in the lapse of geological ages, have come the incredible quantities of loose, yellowish sea-sand, which form the terraced banks of the Sandy River, fill up its valley-bed, and give to it its name.

There are other similar sandrocks,* running horizontally through the hillsides, higher up in the coal measures, and forming crags and cliffs, caves, tables, pulpits, and ship rocks, of the same picturesque pattern; but they are comparatively thin, and of small account compared with the vast stratum through which the cañons of the Upper Paint waters have been excavated; as the cross section (Fig. 1) will best show. Nothing, in fine, is more remarkable about these waters than the absence of boulders and fragments of rock in the beds of the ravines, the smoothness and gentleness of the main streams, and the incredible abundance of sea-sand; and that these features should coexist with the presence of lofty cliffs on every side, from which it would naturally be expected that thousands of fragments would fall and encumber the slopes. But, on the contrary, the homogeneous and friable nature of the strata has permitted the ordinary meteoric agencies, rain, frost, sunshine, and wind, to wear them down piecemeal, powdering up whatever dêbacle occasional uncommon storms might produce, and passing off the entire debris into the lower country of the Sandy and Ohio rivers. For there is no evidence that glacial action has ever had a hand in forming this topography.

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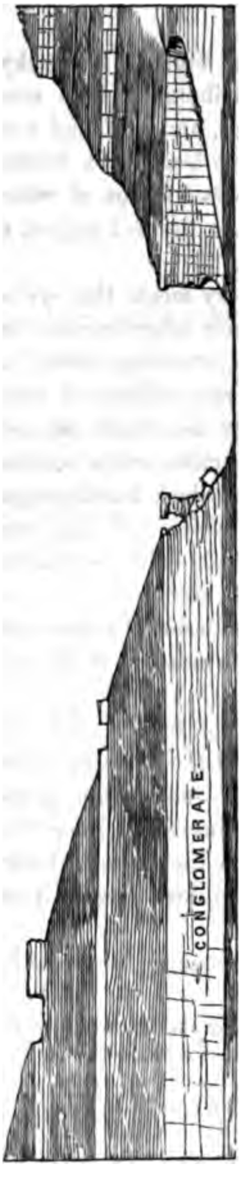
* On Low Devil Creek, a head of Red River, at the 236th mile of the Base Line Survey, and therefore 50 miles west of Paintsville, the Tionista (Freeport?) Sandstone lies 80 feet above the Conglomerate, and is well filled with plant impressions, and has thin coal-seams wedged in between its layers. S. S. Lyon, IV, p. 532.

Fig. 1.



The Coal Measures of the Paint Lick country contain at least four coal-beds; one of them underlying the Conglomerate, and the others overlying it. They are none of them large, but they will serve the purpose of local consumption; and, when fully explored, may prove to be much larger and better than is now known, for the country is in so wild and undeveloped a condition, and the coal-beds of the Lower Coal Measures, to which these beds belong, are so variable, that they may be expected to present different aspects of size and quality on every different hillside.

The following scheme of the beds, showing their Kentucky and their Pennsylvania names in opposite columns, will be useful to enable one to understand them without confusion:

Top Hill Sand Rock = The Mahoning Sandstone.

Coal No. 4 = Pomeroy Coal = Upper Freeport Coal.
Coal No. 3 = Coxe's W. Liberty = Lower Freeport Coal.

Middle Sand Rock = The Freeport Sandstone.

Coal No. 2 = Main Peach Orchard = Kittanning Coal.
Coal No. 1, C = Clarion Coal.
Coal No. 1, B = Wheeler's ? = Brookville Coal.
Coal No. 1, A = Tionista Coal.

MILLSTONE GRIT = No. XII = THE GREAT CONGLOMERATE.

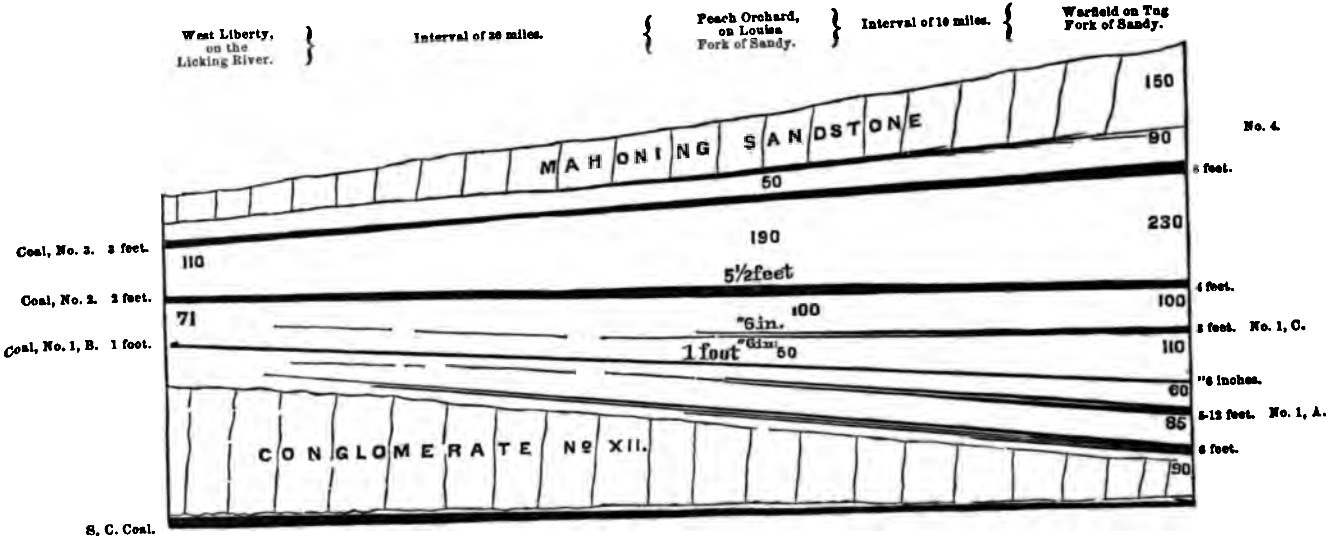
Coal Sub-conglomerate; = No. XI. Coal.

A few of the hills, being capped by the Mahoning Sandstone, contain all seven of these horizontal layers of coal; but the majority of the hills are only high enough to take in Coal-bed No. 2, the Kittanning bed.

It seems to be well made out, especially by the labors of Mr. Lesquereux, that the Coal Measures become thicker, and the coal-beds larger and farther apart, as one pursues them from the Licking Waters, in Magoffin and Morgan Counties, eastward, across Paint Creek, Jenny's Creek, and Louisa Fork, towards Tug Fork and the Virginia country. The accompanying diagram, Fig. 2, gives three of Lesquereux's comparative sections: one at West Liberty; one at Peach Orchard, on Louisa Fork; and one at Warfield, on Tug Fork of Sandy.

The Main Coal of the Peach Orchard mines, 5½ feet thick, seems to be the same bed with that mined on Paint Lick Creek, Wheeler branch, a mile or two west of Paintsville, at

FIG. 2.—EAST KENTUCKY COAL MEASURES.



an elevation of 195* feet above the creek, 4 feet thick (without parting slates), and dipping locally 2° towards S. 80° E.

About the other beds we know absolutely nothing at all, except that one or more of them becomes of great size (6 to 10 feet thick) in the neighborhood of Prestonburg.

The Sub-conglomerate Coal, which is a respectable 4-foot bed in Middle Kentucky,† crops out all along the foot of the Conglomerate cliffs, in the cañons of Upper Paint Lick waters, just above water-level, and of variable thickness, being sometimes only a few inches thick, sometimes yielding two feet of coal, and sometimes showing an outcrop of mere black slate, three or four feet thick.

This is, perhaps, the 6-inch bed of coal which the three wells at Lyon's Steam Mill, at the mouth of Open Fork, are said to have passed through, not many feet beneath the water-level; but I think it more probable that it is a second and lower bed belonging to the Sub-conglomerate System, but of still less practical importance.

A bed of iron ore (blue carbonate of iron) everywhere accompanies the coal and black slate just under the Conglomerate Rock. But this, also—although well developed in Middle Kentucky,—seems to be of small importance on Paint Creek. Near the Lyon Well I saw it as a stratum of balls, 2 to 4 inches thick, enveloped in shales, and lying about 5 feet below the bottom plate of the Conglomerate.‡ The shales are themselves ferruginous, and bog iron-ore springs issue from the edge of the stratum, in many places, forming puddles of yellow slime, which the people call sulphur, but which is merely iron-rust, commonly mixed, also, with oil.

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* Kentucky Reports, Vol. I, p. 210.

† See Joseph Lesley's Report in Kent. Rep. Vol. IV, p. 474. The bed near Proctor, Owsley County, is 42 to 50 inches thick, and is one of a system of Sub-carboniferous Coal Measures, consisting of five (5) beds.

‡ Some charlatan had given the neighbors to believe that it was an ore of platinum. Just as Owen describes "the Swift mine" of silver, near the Tennessee line, as turning out, on examination by him, to be merely dark gray kidney clay ironstone. Vol. I, p. 222. In Estill County, the ore varies from 7 to 24 inches, but rests directly on the sub-carboniferous limestone. Vol. IV, p. 471.

There are two other places for iron ore in the series, but they have not been explored in this neighborhood. *The Buhrstone Ore* of Clarion and Venango Counties, in Pennsylvania, and of the Hanging Rock Region of Ohio, and of Grayson and Carter Counties, in Kentucky, ought to come in between Coal-bed No. 1, C, and Coal-bed No. 2. But the Kentucky geologists conclude from their observations, that this remarkable deposit did not extend itself so far south in this direction.

Another bed of iron ore, however, exists on the hills on the east branch of Jenny's Creek, which probably spreads itself more or less through all the hills of the country. It underlies 30 feet of sandstone and 2 feet of shale; and it consists of a roof of pyritiferous sandstone, 8 inches; black bituminous shale, 1''10; iron ore, 2 to 4 inches; coal, 2''6; underclay, 1 foot.* The inclosure of the iron ore between two bituminous beds, is not favorable to its quality. This is probably the same ore stratum which underlies the Top Hill Rock (Mahoning Sandstone), on the Licking waters,† and the Red River branches, where it is from 18 to 20 inches thick, and of good quality.‡ The situation in the series is precisely that occupied by the Summit Ore stratum of Armstrong County, in Pennsylvania. It deserves to be carefully studied.

Petroleum is the mineral that excites most interest at present in all this region, and the show which it makes upon the surface is extraordinary. It issues in numerous places from the base of the cliffs which form the walls of the cañons through which flow the main Paint and its many branches. It saturates the slopes and banks of loose sand. It flows off, when the sand is stirred with a stick, as a shining scum upon the surface of the stream. It has been caught against booms and barrelled for sale. It unites, also, with the sweepings from the Sub-conglomerate ore and coal shales, and forms slimy ore bogs and muck heaps, where the base of the Conglomerate is at any greater height than usual above the water-bed, and the slope from it is, therefore, longer than usual. Such is the case at the Old Oil Springs, on the north line of the May & Ross Survey, where it crosses the Oil, Little or South Fork of Paint; and again 200 yards lower down, at Pendleton's Oil Spring.

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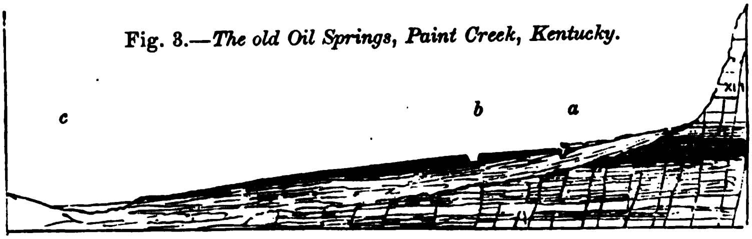
* Lyon's Report, Vol. IV, p. 543.

† Idem, p. 538, 537.

‡ Idem, p. 535.

A black reservoir of tar-like oil here occupies the centre of a sloping bog, and is kept always full from a spring at its upper limit, near the top of the slope and the foot of the cliffs, about 20 feet above the level of the stream. Figure 3 shows the conformation of the ground; *a*, the spring; *b*, the reservoir; *c*, the bed of Paint Creek.

Fig. 3.—*The old Oil Springs, Paint Creek, Kentucky.*

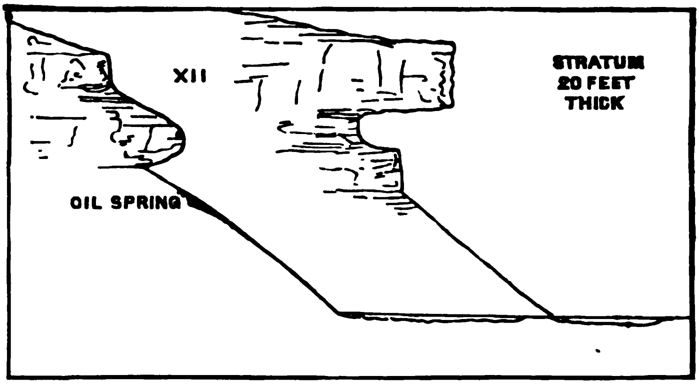


A mile further down the stream, but on the opposite or right bank, and apparently 35 or 40 feet above the water, on a steep slope, close under projecting cliffs, is a similar spring, which has not produced any extensive bog, for want of a level receptacle, but which has yielded "large quantities" of oil in past years, and from which the petroleum continues to run slowly all the time. Fig. 4 shows the contour of the ground and the overhanging cliffs, at two places near the spring.

Three miles further down the stream, and within a mile or less of its junction with the North or Open Fork, at Lyon's Well, the oil is to be seen coming from the edge of the coal- and ore-shales, just under the cliffs, which here tower to an amazing height, especially upon the west, or Emigh Survey side; the survey cornering upon the stream close by, at a stump, at the mouth of a little run. Fig. 5 represents, in a formal manner, this section, and a pile of Conglomerate crag, called the Crow's Nest, between one and two hundred feet high, wonderfully tower-like and regular, opposite.

There are here, immediately underneath the lowest plate of Conglomerate (20 feet thick), 5 feet of shales, then two feet of yellow sandstone, then 1½ to 3 inches of ball ore, then black and blue slates to the creek level. A mile or two up the creek, and perhaps half a mile above the mouth of the Mine Fork, there are in these black slates two distinct beds of coal, 6 feet apart: the upper 10 inches, the lower 24 inches thick; and oil flows from them continually in small quantities. The extraordinary erosion of these valleys could not be studied anywhere to better advantage than at the junction of the Mine Fork with the South Paint. The topography is exactly reversed. The nose of rock making the fork, itself one of the most romantically picturesque piles of pulpit rocks to be found in the United States,* points up stream instead of down, the tributary Mine Fork meeting the main stream fair in the face. (Fig. 6.)

Fig. 4.—*On Little Paint Creek, Kentucky.*



From the Crow's Nest down to the Lyon Well, and further on down the Main Paint, the same appearances repeat themselves. Here are to be seen the old "stirring places," where, before the rebellion broke out and put an end to all manner of trade in Kentucky, Mr. George and others collected oil from the sands, by making shallow canals one or two hundred feet long, with an upright board and a reservoir at the lower end, from which they obtained as much as two hundred barrels per year, by stirring the sands with a pole. The same method has been employed, with like success, as far down Paint Creek as the cliffs continue high; that is, to within six or eight miles of Paintsville.

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* I have given the crag at this point the name of the Propylon, because of its remarkable likeness to that feature of Egyptian architecture.

Fig. 5.

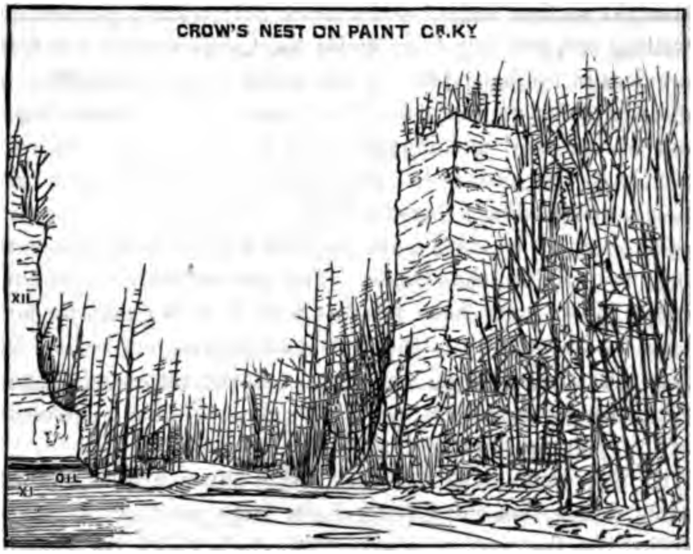
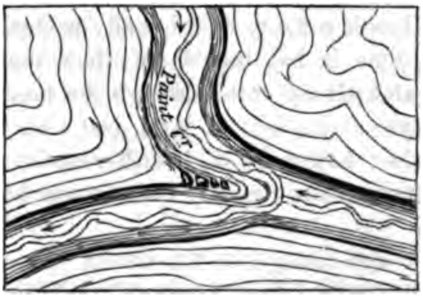

CROW'S NEST ON PAINT CR.KY
XII
OIL
XI

Fig. 6.



At Davis's, where the road crosses Paint Creek, just below the mouth of Little Glade Run, and in the midst of the finest cliff scenery,—the Conglomerate being here 230 feet thick, and the streams flowing at the bottom of it, between long straight vertical walls,*—the black petroleum is perpetually welling out, not only from under the Conglomerate, but from crevices in the bare faces of the rocks, and accompanied, as elsewhere, by yellow peroxide of iron. In the holes scooped out of the sand and mucky banks of the run, the oil rises visibly to the surface in clots, looking not unlike dead tadpoles, which, slowly forming discs, widening and uniting with each other, and covering the puddles with an iridescent coating, flow off into the stream. The painted water is no curiosity, for we have been familiar with it as a guide to coal-beds, and especially to the Sub-conglomerate ore-bed of No. XI, these many years, although we never suspected its connection with petroleum. But the clots of black petroleum are very curious and characteristic.

It is evident, from the description given above, and the same description will answer for a large number of similar springs in the numerous gorges through which the Licking waters find their way westward into the Blue Grass country of Middle Kentucky, that the petroleum of the oil springs of Paint Creek has had its home in the great Conglomerate at the base of the coal-measures; *still has*, we may say; for it is still issuing, in apparently undiminished quantities, from the same. How it came to be originally packed away there; how long a time it has lain there; how much of it has managed to sink slowly down through the mass, and collect itself as a layer at its bottom level, just over or in the ore and coal-shales; how much of it still remains disseminated through the mass; how recently the streams have succeeded in cutting down their cañons to the bottom of the sand mass, so as to afford an exit for that proportion of the petroleum which had there collected to begin its escape; how far the petroleum, in its downward progress, has passed through the ore and coal-shales, and has found still lower horizons to stop it, and is there waiting for the oil-well borers to come and give it issues to the surface; and to what extent, on the other hand, the deeper and older petroleums (of which I shall speak hereafter) have found fissures from below, up which to ascend to mingle with this petroleum of No. XII: these are questions of the greatest practical importance, which no one, so far as I know, has distinctly stated; and they can only be fully answered after long practical investigation.

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* Some of the walled sides of the Little South Fork of Red River are said to be impracticable for seven miles, where it is walled in, nearly perpendicularly, to the height of 200 to 300 feet without a break. The head of the Hotel branch of Graining Block Creek terminates abruptly against a cliff 250 feet high, the chasm being about the same width. S. S. Lyon's Report, K. R. IV, p. 531; 229th mile Base Line Survey.

A Conglomerate age or horizon of petroleum exists: this is the main point to be stated. It must be kept in view apart from all other ages or horizons of oil, whether later or earlier in order of geological time. I have no doubt that some of the petroleum flowing or pumped from old salt wells in Southwestern Pennsylvania comes from this horizon of No. XII. The rock itself is full of the remains of plants, from the decomposition of which the oil seems to have been made. I noticed in the great rock pavement, at the Lyon's Well, over which the creek water flows, many sections of tree branches and stems, mashed flat, each section being, say 6 inches long by ½ inch wide in the middle; and when a jack-knife was thrust down into the slit, so as to clear it of mud, the black tarry oil would immediately exude and spread itself over the water. A pointed hammer spalling off flakes of the rock on each side, showed not only that the slit itself was full of thick oil, but that the whole rock was soaked with it, except along certain belts (an inch or less wide and very irregular), which, for some unexplained reason, remained free from the oil.* Similar specimens of "oil-rock" were obtained in other parts of the valley, and may be got almost anywhere. Mr. Lyon was so much impressed with the quantity of petroleum thus held permanently by the sandrock itself, apart from the immediate presence of the plants, that he actually erected a powerful rock-crusher, and sunk a shaft, by blasting 38 feet, intending to drift in the directions in which he found the saturation to prevail, and to distil the rock after it had been reduced to powder. Of course such a project was most unprofitable; but it well illustrates the abundance of the petroleum held by the friable sandrock. Some of the great blocks of rock which have fallen from the cliffs too recently to be as yet decomposed, are literally full of the marks of the broken macerated driftwood of that period. For hundreds of square miles this vast stratum of ancient sea-sand is a thick packed herbarium of coal-measure plants. My brother, in his report of the counties further west, writes:* "Thin streaks of coal are jammed in between the layers of the base of the Conglomerate, and even inlaid in the heart of the solid rock, all along the line." But if the loose sands of the banks of Paint Creek, derived, as they are, from this sandrock, can at the present day receive and retain vast quantities of petroleum, in spite of the perpetual washings to which they are subjected, we can easily conceive of the wide, flat sandy shores of the coal islands of the ancient Archipelago of the coal era becoming completely charged with the decomposed and decomposable reliquiæ of both the plants of the land and the animals of the sea.

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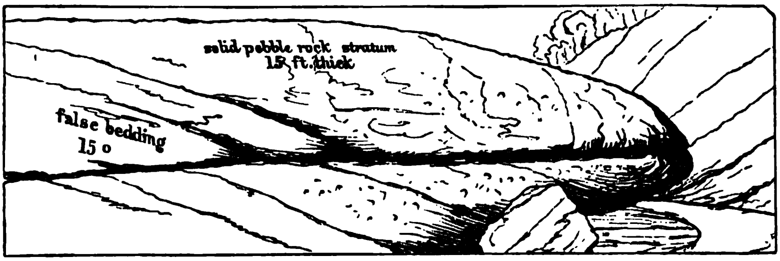
* My specimens still show this very remarkable peculiarity, although I have had them in a dry, warm room for weeks.

The Conglomerate is very irregular in its internal composition, or "false-bedded," even to angles of 15°, or more. Instances are given below, taken from near Davis's House. Under the rock in Fig. 7 Davis's principal oil

Fig. 7.



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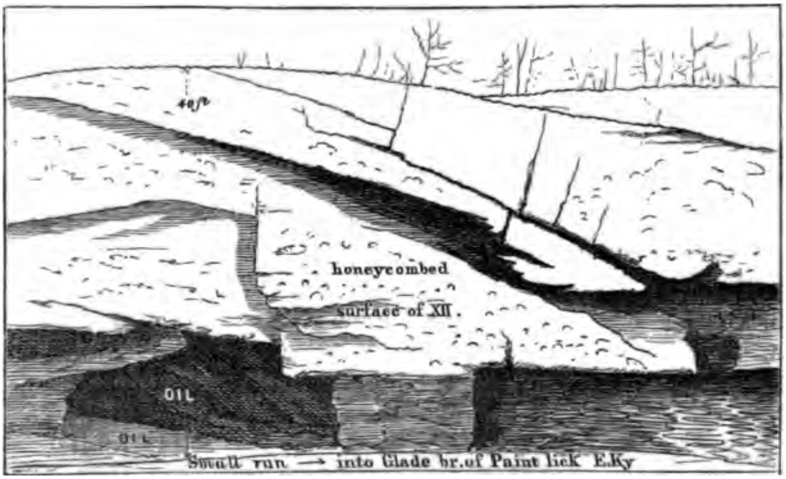
* K. R., Vol. IV, 1858, p. 454.

spring issues, as shown in Fig. 9; it formerly oozed from *x*. The whole lower, shadowed, or overhung portion of the rock, in Fig. 8, exudes oil from its false-bedding joints, as if these surfaces had received and preserved an extra quantity of the organic matter.

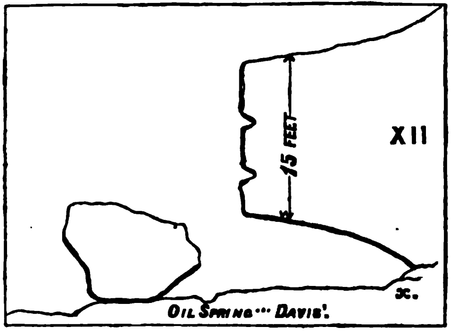
The Conglomerate is, however, still more irregular in the thickness of the whole mass, as was demonstrated on a large scale in 1857 and '8, by Joseph Lesley's survey of the west edge of the coal area, from the Ohio River to the Tennessee State line. He carefully measured the thickness of the sandrock No. XII,.and the shales below it, No. XI, in every county through which the survey passed. On the Ohio River, XII is 90 feet thick, over a few shales, with a thin coal-bed. On the North Fork of Licking, XII is 150 feet thick, over only 8 feet of shales, "with a well-defined bed of iron ore and a foot of coal." On Miner's Fork, 148 feet of XII lies directly on the limestone. In Estill County, XII is 196 feet, over 50 feet of XI shales, with a workable ore-bed and 27 inches of coal. At Standing Rock, XII is 210 feet, over 50 feet of XI. From this on, southwards, XII is never over 80 feet thick, while the XI shales increase to 225 feet, with two workable and three thin coal-beds, with three distinct ore

Fig. 8.



shales.* At Proctor, XII is only 60 feet, while the XI shale mass is even 296 feet thick.†

Fig. 9.



Now I measured the cliffs on Paint Creek in many places, and found the most striking variations. At Davis's, XII is 230 feet thick, the whole of it visible, in a wall composed of two members. Sometimes an upper unbroken wall, of 50 or 60 feet, is retired a little behind the lower and still more massive wall, which rises directly from the bed of the stream. I shall allude to this division afterwards. But the bottom plate is distinctly seen at the water, and the top plate forms perfectly level overhanging eaves to the gorge, on both sides. Only four or five miles above Davis's, at Wash. Webb's fording, the top plate of XII is only 85 feet above the water, and an oil spring issues 10 feet above the water, from under what seems to be the lowest member of XII, 30 feet thick; for at James Williams's, opposite, shales and oil appear. See Fig. 10. At Lyon's place, at the mouth of Open Fork, two or three miles above Webb's, the top plate of XII is 140 feet above the creek; and although the water runs over sandrock, yet shale is struck a few feet down in the well, and the subcarboniferous limestone at a lower depth; while the rocks are normally horizontal up stream, and the ore and coal shales of XI are visible half a mile distant in that direction. I have not the least doubt of the rapid variability of No.

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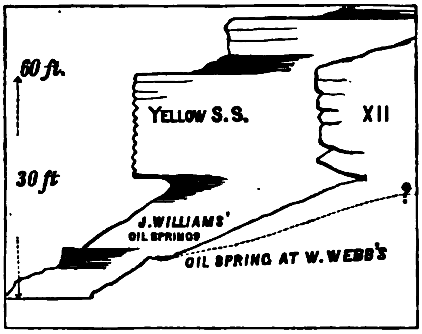
* Kentucky Report, Vol. IV, p. 454. † Idem, p. 478.

XII. And this accounts for the great variations in the aspect of the valley at different places, the appearance and disappearance of cliffs, the commencement and termination of cañons, and the alternate ascent and descent of the margin of arable land upon the hillsides above.

Fig. 10.



Oil wells, then, if bored in the Paintsville country, or in the upper parts of the valleys of the Paint Creek waters, on the Lewis Survey, cannot calculate on any fixed thickness of No. XII to go through. They may find this mass of sandrock 50 feet thick, or 250 feet thick; and the difference must materially affect their production of oil, supposing the oil to reside in this sandrock, or to be collected at its base.

The division of No. XII into two numbers is also important, because this ought to give two horizons of petroleum instead of one. It is remarkable, that all through Pennsylvania the Conglomerate (No. XII) shows a tendency to subdivision into two or more massive sandrock members, separated by somewhat softer or even soft shaly formations. It is evidently a general feature of its character, produced by some universally acting, still undiscovered cause. But one of its effects is to establish a second line of oil springs at a much higher elevation in the cliffs than the one I have been describing. At Davis's, where the upper member of XII is retired a hundred yards or so, at the top of an intermediate slope, the oil is said to exude at all times as abundantly from the base of this upper member as it does from the base of the lower member. This is at an elevation of at least 150 feet above the creek.

So, also, under the numerous cascades which the top plate of the upper member of XII makes, for miles up the valley, there are similar exudations, as if the top member was charged, like the bottom member, with petroleum.

Lower Horizons of Petroleum.—Under the country of Paint Creek and the Licking waters lie the rocks of the Devonian System, the upper part of which is the well-established horizon of the N. W. Pennsylvania oil, and the lower part of which is the equally well-known horizon of the Canada and Michigan State oil. If we can get, therefore, the thickness of measures between the bottom of the Conglomerate, No. XII, and the top of the Devonian Formation, and also the thickness of the Devonian Formation itself, we can approximate to the calculations of the normal depth of oil wells, if bored to reach, first, the Pennsylvania oil, and secondly, the oil of Canada.

This, then, is the first question:—How deep should the Lyon Well, or the Hinckley Well, or the Spradley Well, or any other well starting from the bottom of the Conglomerate, descend, to strike the upper face of the Devonian Sandstone; and how much deeper must it continue to go to reach the Blue Limestone on which the Devonian System rests? When this first question is answered, it does not follow that the oil will be struck at precisely those places in the Devonian System at which it is struck in Pennsylvania, Virginia, or Canada; for that would depend on the continuance, over immense distances, of certain individual oil-bearing rock members of that system. Thirdly, The quantity of oil at any such level will be a local peculiarity, dependent *originally* on the local abundance of organic matter, both animal and vegetable; and, *secondarily*, on the local thickness, coarseness, and general fractured condition of the oil-bearing rock.

To answer this question, it is necessary to state the order of the formations, as follows, descending:—

XII. Conglomerate Sandrock.
XI. Sub-conglomerate, or Lowest Coal Measures.
XI. Sub-carboniferous Limestone.
X. Upper Devonian (Catskill) White Sandstone.
IX. Upper Devonian Red Sandstone and Shales.
VIII. Middle Devonian (Chemung) Clay Sandstones.
VIII. Lower Devonian (Portage, Hamilton, and Upper Helderberg) Olive Shales and Black Slates, viz.:
    Genesee Slate;
    Tully Limestone;
    Hamilton Slate;
    Marcellus Shale;
    Corniferous and Onondaga Limestone;
    Scoharie Grit;
    Cauda-galli Grit.
VII. Oriskany Sandstone.
VI. Upper Silurian (Lower Helderberg) Limestones:
    Onondaga Salt Group;
    Galt Group;
    Niagara Group.
V, IV, III, II, I, it is not needful here to specify.

Enough has been said, perhaps, respecting the Conglomerate; and respecting the No. XI Ore and coal-shale system under it.

No. XI Limestone is the next important formation to consider. Just the reverse of No. XII, and the other sandstone formations, which have their greatest thickness along the Atlantic seaboard, this "Sub-carboniferous Limestone" of the Great West *thins away eastward* (or northeastward) almost to nothing; is scarcely 10 feet thick where it enters Maryland, and not 2 feet thick in Eastern Pennsylvania. But in Southern Virginia it is quite large; and in Middle Kentucky it is twice as thick as No. XII, but, like it, subject to great variations. Only 70 feet thick on Tygert's Creek in Greenup County on the Ohio River, it increases to 400 feet in Clinton County on the Tennessee State line. It is composed of alternating white, gray, and buff-colored layers of rock, varying in quality from the most argillaceous claystone to [illegible] purest limestone. Its lowest strata contain, in many places, large dark green flint pebbles, which seem to have been extensively quarried by the aborigines. Traces of lead are found through its centre beds. The drainage through it is peculiar. The valleys excavated in it are dish-formed, broad, and shallow, and rarely have streams flowing through them; for the waters of the springs above are carried down through sinkholes and cracks in the cavernous limestone, and often reappear only to plunge again and again, before they finally gush out in copious, clear, and never-failing springs, along the junction of its base with the next underlying Knobstone formation, near the mouths of the valleys, as they open towards the Blue Grass country. We have thus valleys which are technically dry, the bottom being a mere series of dry, crater-shaped holes, where cattle graze.* In Bath County (70 miles west-northwest of Paintsville), the valleys are terraced with two lines of springs, an upper line of warm soft water coming from the coal shales under XII (85 feet thick), and a lower line of cold hard water, issuing from the base of the XI limestone,† 140 feet thick. In Powell County (60 miles west of Paintsville), the limestone is thick and cavernous; sinks and caves are seen on every hand; the cavern roofs fall in and let down the upper ore and coal measures, so as often to baulk the miners of their bed, over large areas.‡ On Rock Lick and War Fork, in the north corner of Jackson County (about 45 miles W. S. W. of Paintsville), the great thickness of both the XI Shales and the XI Limestone will be apparent from the following section:*

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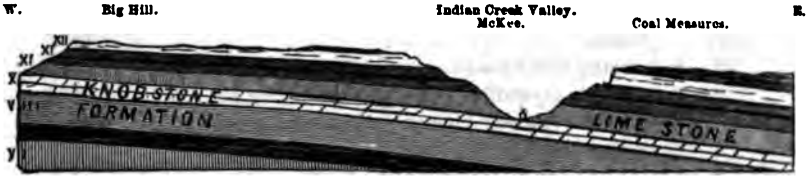
* Copied in substance from J. Lesley, Ken. Rep., IV, 452.

† Idem, p. 466, 467. See, also, the description under the head of Rockcastle County, page 482.

‡ Ken. Rep., IV, p. 472. Between Roundstone Creek and Kentucky River Valleys, in Rockcastle County, where the Conglomerate XII is very thin, and only in fragments on the upland, a remarkable number of holes occur in it, only to be accounted for by reference to the cavernous nature of the underlying limestone, on which it almost immediately rests, the shales of XI having run down from 240 to 40 feet. The No. XI limestone measuring variously 115, 145, 182, 220, and 240 feet, the last in the southeast corner of the county. The "cavernous" member of XI is described as being about 100 feet down from the top of the limestone. I think it possible that the downthrow (of XII) of 150 feet at Davis's Fording may be due to the same cause.

Fig. 11.



It might be argued that this limestone formation is not itself much, if any, concerned in the question of oil, from the fact that the formation is absent in the oil districts of the Ohio River on the Pennsylvania State line; as well as from the fact of its clayey and cavernous constitution, no oil horizon being as yet known in common clay rocks, nor any positive proof having been yet afforded of its collection in caverns so extensive and communicative, and so well drained as those which characterize this formation. But on the other hand, it may be urged: 1, that we do not know to what extent the formation of caverns in it may be confined to the belt of country in which its outcrops permit the cavern-producing waters to escape with their dissolved material; 2, that the Rathbone Well, in Virginia, 700 feet deep, and the Lyon Well, now to be described, both penetrate the limestone, and find in it flows of oil; and its crevices may, therefore, in some regions, play the part of the crevices in the sandrocks which yield petroleum; and 3, that it is crowded with animal organic forms, as can be seen from the following section copied from Mr. Lyon's Report, K. R., Vol. IV, p. 528.

Section obtained on the 218th mile of S. S. Lyon's Base Line.

		Feet.
XII.	Thick, remarkably false-bedded, fine sharp grit-rock, .	10
"	Thin-bedded, sharp grit-rock, ...	11
"	Whitish sandy shales, ...	22
XI.	Ore beds; and gray shales, ...	2
"	Thin-bedded, buff limestone, *indistinct fossils* rare, .	8

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* J. Lesley, K. R., IV, p. 481.

		Feet.
XI.	Thin-bedded earthy limestone, *Retepora*, *Archimedes*, *Pentremites*, ...	2
"	Thick-bedded drab limestone, ...	13
"	? Aluminous and calcareous shales, ...	10
"	Flaggy, whitish oolite limestone; large *Pentremites pyriformis*, ...	10
"	Soft earthy buff limestone; irregular angular fracture,	11
"	Semi-oolitic crystalline limestone, producing red soil, .	22
"	Rough concretionary blue-gray limestone, . . .	10
"	Gray limestone with buff-colored segregations, . .	2
"	Bright buff earthy limestone; no fossils, . . .	4
"	Irregular thin green-gray; no fossils; few chert beds at the top, ...	24
"	Thick-bedded semi-oolitic limestone; top, no fossils, segregations and beds of green flint; lower part, *Pentremites*, *Crinoidea*, *Bellerophon*, *Fish*, ...	22
"	Blue earthy limestone and shales, containing *Corals*, *Spirifera*, *Terebratula*, *Retepora*, *Crinoidea*, . . .	38
"	Soft yellow earthy limestone, ...	56
X.	Soft greenish silicious shale (Knobstone), . . .	32
"	Hard greenish silicious shale, ...	16
"	Hard fine-grained sandstone, ...	16
"	To the bed of Cow Creek, in all, ...	291

The Lyon Well was bored at the point of Paint Creek, where its South, or Little (Oil) Fork, and its North, or Open Fork, unite. The well-house stands on a plate of rock a few feet above the water-bed. A well was blasted through 20 feet of massive sandrock, under which the auger went down through 2 feet of shale, followed (at intervals not now remembered by Mr. Lyon, whose record of the well is lost) by micaceous sandstone, 33 feet of shale, blue sandstone, white marble, and blue limestone, to a depth of 213 feet.* Shows of oil were obtained at 124 feet, 160 feet, 193 feet, and 213 feet. The pump rods came up covered with oil as thick as softsoap, so that a pint of it could be scraped off at a time.[*] The oil obtained at 124 feet was of a specific gravity of 15°, while that obtained at 213 feet had a gravity of 30°.[†] The limestone and "marble" were tested with acids, and undoubtedly mark the place of the upper layers of the Sub-carboniferous Limestone of XI, which nowhere crops out to the surface in all this sandy country.[‡]

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* The men on the ground told me that 30 feet of blue slate rock was the first bored through, beginning, say, 10 feet beneath the bed of the creek; then a thin but very hard rock. They said that this Belt of slate was struck in the three wells on the creek above and below the Lyon Well, viz., the Donnell Well, bored 200 yards below the Lyon well, and 200 feet deep, the second Lyon Well, and the Warner Well, both near together, about half a mile up the Oil Fork, and 100 to 140 feet deep, quitting in hard rock. In the Lyon Well, they thought they struck a very hard thin rock about 140 feet down, and another 260 feet down, whereupon the auger fell 4 inches, and the gas blew the oil to the surface, and it began to flow. Such details from memory are worth little.

The depth of the S. C. Limestone below the Conglomerate may be stated, therefore, from the imperfect record of this well, to be 150 feet; which suits the recorded thickness of the Shales of XI, measured further to the westward. The thickness of the Limestone of XI may be reckoned at about the same; so that the Lyon Well would have struck the top of the Devonian Knobstone Formation, if it had been continued to a depth of from 300 to 350 feet.

It is as yet beyond our ability to distinguish the several original sources of the petroleum obtained at different depths from any one well. The specific gravities of the oil decreasing with the increase of depth, is a fact which shows conclusively that a chronic evaporation or distillation of the whole mass of oil in the crust of the earth (within reasonable reach of the surface) has always been and is still going on,[§] converting the animal and plant remains into light oils, the light oils into heavy oils, the heavy oils into asphalt or albertite;

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[*] I saw several barrels of oil in the well itself resting on the surface of the water. There are from 60 to 100 feet of pipe jammed in the hole, as it was dropped by accident when the well was abandoned on account of the unsettled state of the country.

[†] Mr. Lyon has been a distiller of coal oil, and had a distilling apparatus in his well-house, so that his testimony is entirely intelligent.

[‡] It is, no doubt, the "Marble Limestone" of the main street of Mount Vernon, in Rockcastle County, a fine-grained white limestone, much esteemed by limeburners *there*, lying 40 to 50 feet below the top of the formation, and giving origin to a distinct horizon of springs. K. R., IV, p. 482.

[§] See my paper on the Petroleum Vein of Northwestern Virginia, published in the Proceedings of the American Philosophical Society, Philadelphia, May, 1863, Vol. IX, p. 185.

the process being accompanied at every stage with the generation of gas. Therefore, the quantities of lubricating oil coming out from the Conglomerate, along the valleys of Paint Creek, prove the existence of immense quantities back from the cliffs in the rock itself, under all the highlands. And for the same reason, the heavy oils obtained first from Lyon's and Donnell's and Warner's wells, followed by lighter oils from a greater depth, prove the existence of yet uncalculated quantities of still lighter oils, at still greater depths; and of a world of gas-pressure which ought to make its presence known wherever there have been rents in the crusts, downthrows, fallings-in, or serious slopings of the stratification; in a word, any sort of natural vent.

Burning springs are instances of this very thing. One on Licking River, 4 miles above Salyersville, the court town of Magoffin County, and only about 12 miles in an air line southwest from the Lyon Well, has been celebrated since the settlement of Kentucky.*

Another still stronger burning spring exists at a distance of 35 miles in the opposite direction, one mile above Warfield, in the bed of the Tug Fork of Sandy, on the Virginia State line.†

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* This Spring was described to me by Mr. Patrick, whose house (16½ miles from Paintsville by road) stands half a mile higher up the valley. It stands about 15 feet above water-level, in a dry place, the ground being burnt around it. The gas roared continually, and, when fired, would blaze 40 feet high. No oil was known there until a well was bored, from which the principal part of the gas now blows off, roaring and fluttering in it, so as to be audible for one or two hundred yards, scaring timid horses, before the well is within the rider's sight, and distinguishable by the smell for a quarter of a mile to leeward. The rock was found to be fissured in all directions to a depth of 3 or 4 feet, so that a knife could be thrust into the cracks. The auger went through about 150 feet of sandstone, &c., and is said to have got oil at every change of rock, and to have dropped 1½ inches at the end, where oil and water rushed up, so that from 500 to 1000 barrels were estimated to have run off per year. The rebellion put an end to operations. A second well was put down 100 yards distant down the stream, 130 feet deep, more or less, which got oil; and a third well at Patrick's house, 160 to 170 feet deep, which only got a small show of oil with some gas. These are the only wells in the county, except a fourth at the extreme west end of it.

† This Burning Spring is in 15 foot water, the whole of which is kept

These facts alone would suffice to prove the ground under the Paint Creek country charged with gas. But we have nearer evidence.

The Spradling Well, 4 miles up the creek from Paintsville, and 9 miles down the creek from Lyon's Well, on the Mud Fork of Paint, ¾ of a mile above its mouth, blows gas continually, which burns when lit.*

The whole of this section of Eastern Kentucky is, in fact, an underground oil region. Judge Harris's well, opposite Prestonburg, in Floyd County, 12 miles up Sandy River, above Paintsville, was bored about 600 feet deep for salt, and abandoned on account of the great flow of oil in 1845. The only record preserved was the fact of going through

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in a state of ebullition by the gas, which, when fired, will blaze up as high as a man. When the stream is frozen over, holes are broken in the ice to fire the gas. Two wells have been bored in Warfield, 20 rods apart, in one of which the auger dropped 14 inches, at about 300 feet, six years ago, and the poles were greased with the ascending oil. The other well flows oil into the stream. Each gets salt water at about 800 feet. There seems to be a fault across the Fork, which throws the big coal-bed under for nearly 4 miles.

* D. D. Owen thus describes a burning spring in Clay County, in his Kent. Rep., Vol. I, p. 217, as "a constant stream of gas escaping in copious volumes through a pool of water, in a narrow bottom. A lighted match suffices to set the gas on fire, which flashes instantaneously into numerous jets across the pool, continuing to burn until the gas or a gust of wind blows it out. Judging from the color of the flames and the odor of the gas, it seems to be a mixture of heavy and light carburetted hydrogen with some free or uncombined hydrogen. The commotion in the water rendered it too turbid, without filtration, to test it satisfactorily for its saline constituents. Bicarbonate of iron seems to be its principal constituent. The gases must here reach the surface from some deep-seated source, through an extensive fissure of the rocks concealed by the debris from the hills,—perhaps from some bed of coal or iron ore exposed to surheated steam, or other heat. . . . The elements must be contained in the interior of the earth on a vast scale, since the Burning Spring has continued to evolve these gases with unremitting energy ever since the country was known to the first settlers." Through sand and shales of the coal measures, seven salt wells, yielding 130,000 bushels of salt per annum, penetrate to a depth of 1000 feet, getting brine at 121, 240, 293, and 552 feet; at which last depth the strongest is obtained, the auger dropping into cavities from which the brine, black with a carbonaceous sediment, gushes out, and afterwards grows clear.

black slate. Oil issued also from the Mayo Well, bored about 100 yards distant. These are the only wells in all that valley. On Shelby Fork, of Sandy, in Pike County, oil flowed from a salt well.

It is still doubtful whether the Knobstone formation which immediately underlies the Limestone, is the receptacle of this wide-spread petroleum, or whether we must seek the true horizon in the Blackslate formation which underlies the Knobstone in its turn.

No. X Knobstone formation (consisting of two parts, an upper Sandstone division, and a lower shale division) outcrops in a belt overlooking the Blue Grass country, and measures from 350 to 550 feet in thickness. The upper portion is a thin-bedded, olive-colored, generally fine-grained Sandstone, furnishing good grindstones sometimes, and always building-stone. The lower and larger portion is an olive-colored mud-rock, with pretty generally disseminated nodules of earthy iron ore, from which come most of the Chalybeate Springs of Eastern Kentucky. The upper member seems to correspond to No. X, and the upper half of No. VIII, in which lie the three oil sandrocks of Venango County, Pennsylvania (No. IX being entirely unrecognizable). But the difference of thickness throws us out of all our calculations; for these 350 to 550 feet in Kentucky stand as the representatives for at least 2000 feet in Northwest Pennsylvania, and for 12,000 feet in the Anthracite coal country. The Venango County First, Second, and Third Sandrocks, which have become so celebrated, occupy three horizons in the upper, or as perhaps we should rather call it, the middle part of VIII, lying at maximum depths of 200, 400, and 600 feet respectively beneath Oil Creek Valley bed, but 700, 900, and 1100 beneath the bottom of the Conglomerate, which there caps the hilltops on each side of the Valley. The section represented in Plate II will show this relationship of distances farther down the Alleghany River, at Brady's Bend, where the Conglomerate has reached the level of the Valley bed, and is, therefore, in the same relative position as on our Paint Creek waters. But if, as is pretty certain to be the fact, the Shales of XI and the Limestone of XI, taken together, are only 300 or 400 feet thick, and the Knobstone is 350 to 550 feet thick, then the top of the black slates under the sandstone *might* be struck at the depth of the *First* Venango Sandrock (700 feet), and certainly would be at the depth of the *Third* (1100 feet), or even of the *Second* (900 feet).

It is evident, therefore, that all reference to the "Three Sandrocks" of the Oil Creek country is useless for countries to the southwest of it, and will be made only by those who are ignorant of the general bearings of the subject.

We can only say, that part of the 350 to 550 feet of Knobstone Form., X and VIII, represents the Oil Creek Formation, and, perhaps, contains one or more like horizons of oil; but whether in one, two, three, or what number of oil-bearing sandrocks, separated by oil-preserving shales, nothing but actual experiment can determine.

It is probable that the wells which penetrate the Limestone XI get their petroleum partly from the Conglomerate above, descending with the drainage waters. But it is still more likely that they get their principal amount of petroleum from the Knobstone Formation below, by a system of fissures similar to that of the Venango Oil region. In any case they are bound to prove productive; and I have not the least doubt that wells, sunk 600 to 800 feet along the Paint Creek Valley, will produce reasonably profitable amounts of Upper Devonian Petroleum, steadily, for an indefinite number of years; and this petroleum will be, of course, light oil, and not the heavy oil of the Paint Creek Valley surface.

The amount of petroleum capable of being held by rocks themselves is far greater than people imagine. They hold it in three ways: 1. By being more or less gravelly and porous throughout; 2. By being cracked in systems of cleavage planes throughout; 3. By being traversed by large fissures, which are, probably, all of them merely enlargements of cracks along the cleavage-planes.

Every foot of gravel-rock may be considered to consist of three-fourths quartz, &c., and one-fourth cavity, cleaned by long percolation, and now occupied by water and

The proportion which the oil bears to the water in the gravel is unknown, but must be far greater than in the 80 feet of sandrock (taking one of the Venango oil rocks as a base of calculation) at the top of which the gravel lies; for the oil will settle in these top layers of gravel, while the water remains in the body and lower layers of the sandrock. If the proportion in all be 1 to 100 (for the sake of the calculation), the proportion in the gravel may be 1 to 10, and in the few inches at the extreme top, even 10 to 1. If we should suppose only the uppermost four inches of the whole formation charged with pure oil, that would give an absolute layer of oil one inch thick underspreading the whole country as far as the sandrock extends, or about 4000 millions of square inches under every square mile, or, in other words, 17⅓ millions of gallons = 551,706 barrels. ***Each sandrock*** should be able to supply from ***each square mile*** of its area, the whole present oil produce of the United States for ninety days before it is exhausted, and that without any reference to the accumulation of petroleum in fissures.

Let us carry the calculation a little further, by taking now the fissures into consideration.

The Paint Creek country is one of the most undisturbed on earth. But the drying and hardening to which they are subjected through geological ages crack all rocks; and necessarily in three directions. Two of these directions are always and necessarily nearly vertical, one of them again, being the direction of the primary or master system, going down straighter and deeper, and giving origin oftener to large fissures and downthrows.*

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* The downthrow at Davis's, the petroleum vein on Hughes' River, and other faults and fissures of magnitude in this part of the Bituminous Coal area, all belong to the same almost east and west system of cleavage-planes observable in the Alleghany River country.

In one great fissure (4 feet wide) of this east and west system on Hughes' River, the Devonian petroleum which underlies the Kanawha country (precisely as it underlies the Paint Creek country) has collected itself and hardened into asphalt, before the Kanawha valleys were scoured out. There stands this vertical, east and west running vein of solid petroleum, an evidence both of the abundance and of the antiquity

All clefts in sandrocks must, as a general thing, remain more or less open; and they are the great channels of rapid underground drainage. Fissures in shaly mudrocks are closed as fast as made by the plasticity of the mass, and by the perpetual percolation of fine clay into them. Those which penetrate coal-beds, for instance, are almost all filled up with clay from the overlying shales; while many of the fissures in the coarser sandrocks are only choked with loose sand or small water-worn pebbles. All these are permanent reservoirs of salt water and oil.

The law governing the number of these cleavage-planes is a simple one; the distance of the clefts from one another is, in the main, proportionate to the massiveness of the strata which they divide; that is, the cleavage-planes of the great beds of massive sandrocks lie much further asunder than those of the thin-bedded sandstones; while those subdividing beds of shale are still closer to each other and more numerous.

The law governing the size or width, and also the length and depth of the fissures, is an analogous one: the great sandrocks exhibit clefts sometimes many inches in width, and running many yards or hundreds of feet continuously. The pressure of these rocks sometimes carries their cracks down (or up) through the softer and thinner beds, and the strain of the dip will even cause these cracks to descend many fathoms below where they originated.

Some of the main fissures are known to be four inches wide. Suppose them to be of all sizes, from four inches to a quarter of an inch in width, and at various distance asunder, from 5 to 50 feet, and to be limited to the sandrock itself, say 30 feet in height; suppose we take the contents of the fissures equal to $\frac{1}{300}$th mass of the rock. Now, supposing the oil to occupy but $\frac{1}{10}$th of the space in each fissure, the rest being occupied by water and gas, we have a yield of oil

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of the Devonian Petroleum. It contains at least 200,000 tons of asphalt (allowing it to go only 600 feet deep beneath the valley which it crosses); able to yield by distillation 178 gallons of refined oil to the ton of 2400 lbs., and therefore over *eleven millions of barrels* of refined oil; a quantity which would allow a Noble and Delamater Well to spout 6000 barrels per day for five years.

from each square mile of each sandrock, in addition to that above, amounting to nearly 50,000 barrels of oil. This is at the lowest calculation. In the case of a well yielding one or more thousand barrels of oil per day, for a year or years, we have only to imagine a single four- or five-inch fissure crossing the upper and lower rocks to a height or depth of one or two hundred feet, and extending a mile or two in length, the oil contents of which will amount to millions of barrels, apart from all side supplies. Along the line of one such fissure, it is easy to see that a dozen first-class flowing wells might last for several years. By ordinary wells it would be practically inexhaustible.

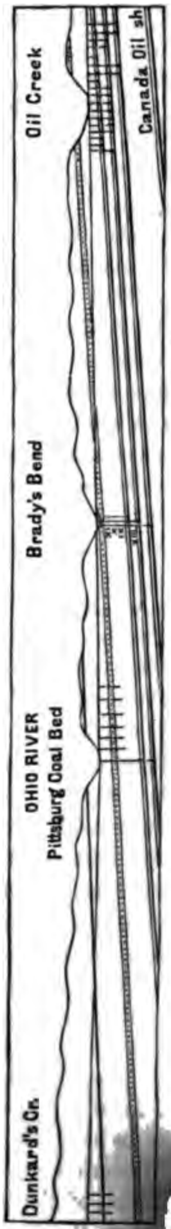
It is not upon these exceptional fissures that the future trade will rely; but upon the myriads of cleavage-planes and cross-cracks which break up the whole crust into cubes, so far as it consists of sandrocks. The number of grand open fissures must be very small; the number of first-class flowing wells is as yet extremely small,—one or two dozen out of five or ten thousand wells in the Oil Creek region. I judge that not more than one well in ten or twelve yields more than one barrel of oil per day. The large majority of the wells must necessarily depend for their supplies upon the slow circulation of the mingled fluids, salt water and oil, forever going on, exhausting and refreshing itself in the porous and cracked body of the sandstone formations. But in this very fact we have a guarantee for the genuineness of the area under discussion as an oil region, the certainty of obtaining petroleum by boring, and the protracted continuance of the supply for many years. All sand and gravel beds are mere sponges, perpetually saturated with oil and water, the mingled fluid being slowly driven towards every available outlet by the gas which is generated with and from the oil. Such spongy rocks must be enormous reservoirs of petroleum, which it is in fact almost impossible for man to exhaust, as I have shown above.

The Canadian petroleum occupies a still lower horizon than the Venango County petroleum, the distance between them in New York and Pennsylvania being variously estimated at from 2000 to 3000 feet. Its general relationship to the higher horizons is shown in Fig. 12. The Venango oil rocks run up nearly a thousand feet over the level of Lake Erie; the black slates and corniferous limestone of the Canada oil come up from below the bottom of the lake to the north. Wells at Erie strike the oil at 900 feet.

But in Kentucky the black slates of the Canadian oil region underlie the Knobstone formation, and are, therefore, as I have shown, only from 650 to 950 feet beneath the Conglomerate in the bed of Paint Creek.

How far this black slate formation has supplied the Knobstone above it with petroleum, is a question that our science is not at present qualified to answer. But that it is a distinct horizon of oil every one grants. It has yielded copiously in Canada. Several wells, in Middle Kentucky, sunk in it, have yielded a constant flow.* It is in fact a great deposit of mud, charged with carbon to such extent that many of its layers will burn like coal, and even thin beds of true coal exist in it here and there. These are of course the remains of vegetation. But that they have furnished all the 5, 10, or 15 per cent. of carbon which we find in the formation, is doubtful, in view of the early age in which it was deposited, the abundance of animal life in the limestones under it and in some of its own layers, and the peculiar quality of the Canada oil which proceeds from it or from the limestone under it.

Fig. 12.



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* In Estill County, one well was ruined by the force of gas. Another, bored by S. T. Vaughn, 405 feet, went through soil 15 feet, black slate 100, light clay limestone 100, gray limestone 190 feet, when the auger dropped, salt water gushed out, and soon gave place to the present constant stream of oil. K. R., iv, p. 472.

The total concealment of the Devonian system beneath the Great Bituminous Coal Area, renders it impossible to speculate with confidence upon the details of those changes in its constitution, which we know occur, in passing from its eastern outcrop (along the Alleghany Mountain) to its western outcrop in Ohio and Kentucky. With the exception of the two anticlinals of Chestnut Ridge and Laurel Hill, which, in their passage from Pennsylvania into Virginia, lift above water-level a few hundred feet of the top measures, in the Gaps of Two Lick, Yellow Creek, Black Lick, the Conemaugh, the Loyalhanna, and the Youghioghany, we are entirely dependent upon oil and salt well boring records for any knowledge of the condition of things in the Devonian underground; how far its salt water and oil-bearing sandrocks extend, each one for itself; the rate at which the intervals diminish in a west-southwest direction; and in what parts of the formation the greatest diminution of thickness takes place.

But, unfortunately, almost all the old records of salt borings are lost; and very few new wells have been sunk by men who knew the importance of keeping any other than a contract account for number of feet sunk. It is impossible to estimate the loss which geology has suffered during the last six years from this reckless ignorance. The inaccessible Devonian strata have been probed by between ten and twenty thousand augers, to depths varying from a hundred to a thousand feet, and no record kept of all that priceless information. It was allowed to flow off into the ocean of forgetfulness, as the oil itself was allowed at first to flow by thousands of barrelsful per day into the Gulf of Mexico. And even now, that men of intelligence have waked to the importance of the fact, most wells are still sunk by contract, without any provision for compelling a careful record of the strata. Nor is there any bureau in the State, any society, or any individual, publicly known to charge themselves with putting to common use, or even with accepting for preservation, what few records are made and kept.

It is with peculiar satisfaction, therefore, that I can publish in the Proceedings of this Society, an authentic record of the deepest recent well in Clarion County, Pennsylvania, and, in fact, the deepest that I know of in the country lying south of Oil Creek Valley. We owe it to the enlightened forethought of one of the master minds of Western Pennsylvania, Mr. Wm. M. Lyon, joint owner with Shorb & Co., of the large Rolling Mill on the south bank of the Monongahela River, and of numerous furnaces and forges in the middle and western counties of the State. At one of these, Sligo Furnace, on Licking Creek, Piney Township, 10 miles S. S. W. of the county seat of Clarion, and 23 miles in a straight line S. S. E. of Oil City, a well was sunk for oil, which has reached the depth of about one thousand feet, passing through the following rocks:

Salt Well, Sligo Furnace.

			Ft. In.
From surface to rock,		14,,07	
Soft light-colored slate,		22,,05	37,,00
Black slate,		4,,07	41,,07
Hard sand rock,		7,,05	49,,00
Soft black slate,		6,,00	55,,00
Hard sand rock,		6,,00	61,,09
Sand rock and slate,		3,,03	65,,00
COAL,		1,,09	66,,09
Coarse sand rock,	XII	2,,00	68,,09
Fine hard " "		21,,05	90,,02
Coarse soft " " and water at 128 feet,		93,,02	183,,04
Hard slate,		10,,00	193,,00
Soft "		74,,08	268,,00
Soft red slate,		2,,00	270,,00
Soft sand rock,		10,,00	280,,00
Slate,		90,,00	370,,00
Close-grained blue sand rock, salt 38 per cent.,		20,,00	390,,00
Slate,		49,,00	439,,00
Hard blue sand rock and salt,		27,,00	466,,00
Soft slate, sooty substances, with smell of oil,		84,,00	750,,00
Soft red slate,		5,,00	755,,00
Hard sand rock [first Venango rock?]		10,,00	765,,00
Blue slate,		21,,00	786,,00
Red "	IX ?	29,,00	815,,00
Blue "		77,,00	892,,00
Red "		2,,06	894,,06
Brown "		30,,06	925,,00
Alternately hard and soft slate, oil,		45,,00	970,,00
Slate,		22,,06	992,,06

Last boring done not measured. The hole is less than 1000 feet.

N. B. The mouth of the well is 175 feet below the Buhrstone Ore-bed level (all the rocks being nearly horizontal); below the ore, 30 to 40 feet, lies the Clarion coal; above the ore, 25 feet, the Kittanning coal; above this again, 50 feet, the general surface of the country.

Now it is evident that the mass of sandrock from 68.09 to 183.04, represents No. XII, the Millstone Grit, or Great Conglomerate, 116 feet thick, from the midst of which (128 — 68 = 60 feet below its top layer) there was a flow of salt water. The 74 feet of soft slate under it, and then 2 feet of red slate, seem to represent No. XI. There is no sign of the Sub-carboniferous (XI) Limestone of the West here; although no test for lime seems to have been thought of, and, therefore, the close-grained blue sandrock, 20 feet, may be calcareous. The "red slates," at 750 — 755, 786 — 815, and 892 — 894, look like representatives of Formation IX. The "hard sandrock," 10 feet, at 755 — 765, is the only one in the section which can be considered as occupying a position analogous to that held by the first sandrock of Oil Creek. It lies (755 — 183 =) 572 feet below the base of the Conglomerate (taken as above at 183), which is more than 100 feet less than its observed distance beneath the Conglomerate on Oil Creek; but the discrepancy may be accounted for *partly* by the extra thickness here of the Conglomerate. Neglecting the "sooty substance, with smell of oil" at 750, the first show of oil is at 970 feet, or (970 — 183 =) 787 feet below the base of the Conglomerate, corresponding to the Second Oil Rock of Oil Creek, which is about 900 feet beneath the Conglomerate. The place of the Third Oil Rock, and principal horizon of oil on Oil Creek, will, therefore, be at least 150 feet beneath the extreme depth to which this well has been sunk.

Mr. Lyon has furnished, also, a complete record of another important well, 891 feet deep, sunk into the extreme upper part of the Devonian Measures, on the Alleghany River, at Freeport, 25 miles above Pittsburg, and, therefore, 50 miles due south of Oil City.

Strata bored through in Salt Well, on Alleghany River, 25 *miles above Pittsburg. Working coal stratum* 3'6" *thick in the hill,* 35 *feet above surface at the well.*

		Ft. In.
Well, through loam and sand,	81,,00	
Rock, blue and hard,	0,,10	81,,10
Blue sand rock, with 8 to 10" iron ore,	16,,10	48,, 8
Gray sand rock, softer,	20,,06	69,, 2
Blue slate rock,	18,, 8	87,,10
Blue sand "	14,,10	102,, 8
COAL,	,,10	103,, 6
Fire clay,	6,, 8	110,, 2
White slate,	9,, 6	119,, 8
LIMESTONE,	4,, 0	123,, 8
White slate rock,	3,, 0	126,, 8
White sand rock,	16,, 0	142,, 8
Blue slate "	3,, 6	146,, 2
COAL,	0,, 6	146,, 8

Fire clay, or white slate rock,		21,, 0	167,, 8
Blue sand rock, very hard and fine,		12,, 6	180,, 2
Blue slate " with balls of iron ore,		10,, 0	190,, 2
Black slate,		24,, 0	214,, 2
Blue slate harder,		5,, 0	219,, 2
COAL,		4,, 4	223,, 6
Fire clay,		6,, 8	230,, 2
Blue slate,		12,, 6	242,, 8
BIMESTONE,	F. L. ?	10,, 6	253,, 2
Fire clay,		7,, 0	260,, 2
COAL,		3,, 4	263,, 6
Fire clay,		2,, 0	265,, 6
LIMESTONE,		5,, 0	270,, 6
Fire clay,		1,, 6	272,, 0
Hard blue sand rock, fine grain,		9,, 6	281,, 6
White sand rock,	T. S. ?	87,, 0	818,, 6
Corrected measurement, for stretching and shrinking of the rope, to be added,		16,, 0	884,, 6
Blue sandrock, with nodules of iron ore,	XII ?	89,,10	424,, 4
Black slate rock,		10,, 2	434,, 6
Blue slate "		6,, 0	440,, 6
White sand,	XII ?	18,, 0	458,, 6
Blue slate rock,		29,, 0	487,, 6
White sand,		7,, 8	494,, 6
Blue slate, soft,		8,, 0	497,, 6
Gray sand rock,		4,, 0	501,, 6
Blue slate "		6,, 0	507,, 6
Hard gray slate rock,		19,, 0	526,, 6
Blue rock, 34'00"—very hard, 41'9",		75,, 9	602,, 3
Gray rock,		89,,11	642,, 2
Black slate and COAL,		8,, 8	645,, 5
Gray sandrock,		8,, 9	649,, 2
Blue sand and white, very sharp,		8,, 9	657,,11
Gray sandrock,		9,, 0	666,,11
Blue sandrock,		3,, 0	669,,11
LIMESTONE,	S. C. ?	3,, 0	672,,11
Slate, and nodules of iron ore,		28,, 8	701,, 7
Blue sandrock,		21,,11	723,, 6
White slate,		10,,10	734,, 4
Blue sandrock,		79,,09	814,, 1
LIMESTONE (supposed),		7,,08	821,, 9
Blue sandrock, hard,		23,,10	845,, 7
White sandrock coarse,		4,,02	849,, 9
Blue slate,		4,,10	854,, 0
Blue sand,		10,,02	864,, 9
White slate, with iron ore,		11,,08	876,, 5
Light blue sand stone,		14,,08	891,, 1

In the above section, begun in the Freeport Series, it seems necessary to take the 10′6″ limestone at 242′—253′ as the Ferriferous Limestone of the Clarion Series, and the 37′ white sandrock at 281′—318′ as the Tionista sandstone. The Conglomerate, No. XII, will then be represented by the 89′ of "blue sandrock with nodules of iron ore," or the two "white sands" further down, or by both, in which last case, we have a total thickness of XII (494 — 334 =), 160 feet. From this to the bottom of the well is (891 — 494=) 400 feet; not enough by 200 or 300 feet to reach even the first of the Venango County oil sandrocks. But in these 400 feet we see black slate and coal (at 645), and limestone (at 672), apparently representing the sub-conglomerate coal shales and sub-carboniferous limestone of Kentucky, No. XI. Thick strata of so called "blue" sandrock, seem to take here the place of No. X; and the bottom of the well may, perhaps, with propriety be said to stop in the upper layers of VIII. Everything depends upon the rapidity with which the Devonian and Sub-carboniferous formations are thinning in their course, southwestward, from Northern Pennsylvania towards Kentucky. The coarse white sandrock at 845—849 must be observed.

It is at Tarentum, near this section, and on nearly the same level with it, that the old salt-wells were so much tormented with oil, that their proprietors contracted for its constant removal with Mr. Samuel M. Vier, of Pittsburg, seven years before Dwight struck oil at Titusville. From his skimming of these wells, Mr. Vier made what he called "carbon oil," which he refined by a process of his own, and sold quietly with the camphenes and burning fluids of the East, until it won the market. At first his oil was sold in twenty-five cent bottles as a medicine; and then as an oil for lamps. To Mr. Vier, who had made a large fortune, and retired from the field at its beginning, the oil-well excitement was, of course, a matter of great amusement. But the history of his process is the best illustration we could have of the permanent supply to be expected from those Alleghany River wells which penetrate deeply enough the Devonian measures.

Mr. Lyon furnishes the record of one more well still further south, and only 354 feet deep, and entirely in the Coal Measures, which, however, ought to be preserved, continuing, as it does, upward to the water-level at Pittsburg, our knowledge of the minutiæ of the Palæozoic column, from otherwise inaccessible depths, to where it can be studied in the open air. The absence from this section of any

thick coal-bed, corresponding to the large coal-beds of the Freeport series, is very remarkable.

Record of Boring at Superior Iron-works at Manchester, adjoining Alleghany City, opposite Pittsburg, McClure Township, Alleghany County, Pennsylvania.

Material.	Ft.	In.	Ft.	In.	Material.	Ft.	In.	Ft.	In.
Surface, . .	14		14		Blue clay, . .	13	2	187	6
White hard slate, .	10	6	24	6	Dark slate and fire clay,	9	10	197	4
Hard free stone, .	3	6	28		Dark slate, . .	2		199	4
Soft black slate or shale,	8		36		Slate and fire clay,	8	6	207	10
" with streaks sulphur,	14	3	50	3	Quartz, . .		1	207	11
Soft dark sandstone,	1		51	3	Slate with hard ribs,	8		215	11
Hard "	1	2	52	5	Hard white cry'd slate,	17		232	11
Dark slate, . .	9	1	61	6	COAL, . . .		10	233	9
Dark fire clay, . .		9	62	3	Fire clay, . .	4	3	238	
Light slate, . .	3	2	65	5	Hard crystallized slate,	2		240	
Fire clay, . .		7	66		Soft fire clay, .	4		244	
Dark slate, . .	1	6	67	6	Soapstone, . .	5	6	249	6
Slate with hard rib,	9		76	6	Fire clay, . .	4	6	254	
Fire clay, . .	5	4	81	10	Hard clay rock, .	11		265	
Sandstone, . .	1	2	83		Dark slate, . .	9		274	
Fire clay, . .	7		90		Hard light slate, .	1	6	275	6
Blue slate, . .	2	10	92	10	Dark slate, . .	2	6	278	
Free stone, . .	2	2	95		Dark sandrock, .	3	6	281	6
Light blue slate, .	17	6	112	6	" hard and soft ribs,	4		285	6
Dark clay, . .	5	3	117	9	White sandrock, .	1	6	287	
COAL, . . .	1	9	119	6	Hard " .	2		289	
Blue clay or slate,	8	6	128		Dark " .	25		314	
Fire clay, . .	18		146		Wild coal, . .		4	314	4
Sandstone, . .	8	4	154	4	Black shale, . .	3		317	4
Fire clay, . .	2		156	4	Fire clay, . .	9		326	4
Hard sandstone, .	2		158	4	Slate, . . .	4		330	4
Poor iron ore, .		6	158	10	Dark clay rock, .	10		340	4
Dark slate, . .	3	6	162	4	Hard dark sandrock,	2	8	343	
Dark sandstone, .	10		172	4	Dark slate, . .	11	2	354	2
Very hard " .	2		174	4					

Mr. Chase has obtained the following record of a Salt Well bored in 1840–1, at Latrobe, in Westmoreland County, on the Pennsylvania Railroad, 30 miles east of Pittsburg. It is called Saxman's Salt Well, and has been long abandoned. The Pittsburg Coal-bed, 8 feet thick, lies 10 feet above the level of the mouth of the well:

Soil, &c., ...	**15 feet.**	
Slate rock, blue, soft, ...	**1**	
Sandrock, blue, close, 3; somewhat softer, 3, . . .	**6**	
Slate rock, sandy, blue 2; slate, blue, 5, ...	**7**	
Sand rock, blue, 7 (white flint 2 inches), ...	**7**	
Black, slate-like COAL, 1''10, ...	**2 =**	**38**
LIMESTONE, with some ore and mud veins, . . .	**19**	
Slate and sandrock, mostly blue, some almost black, silvery sand came up, *gas vein struck at* 85,,10, *which boiled for two hours and then stopped*, ...	**69 =**	**126**

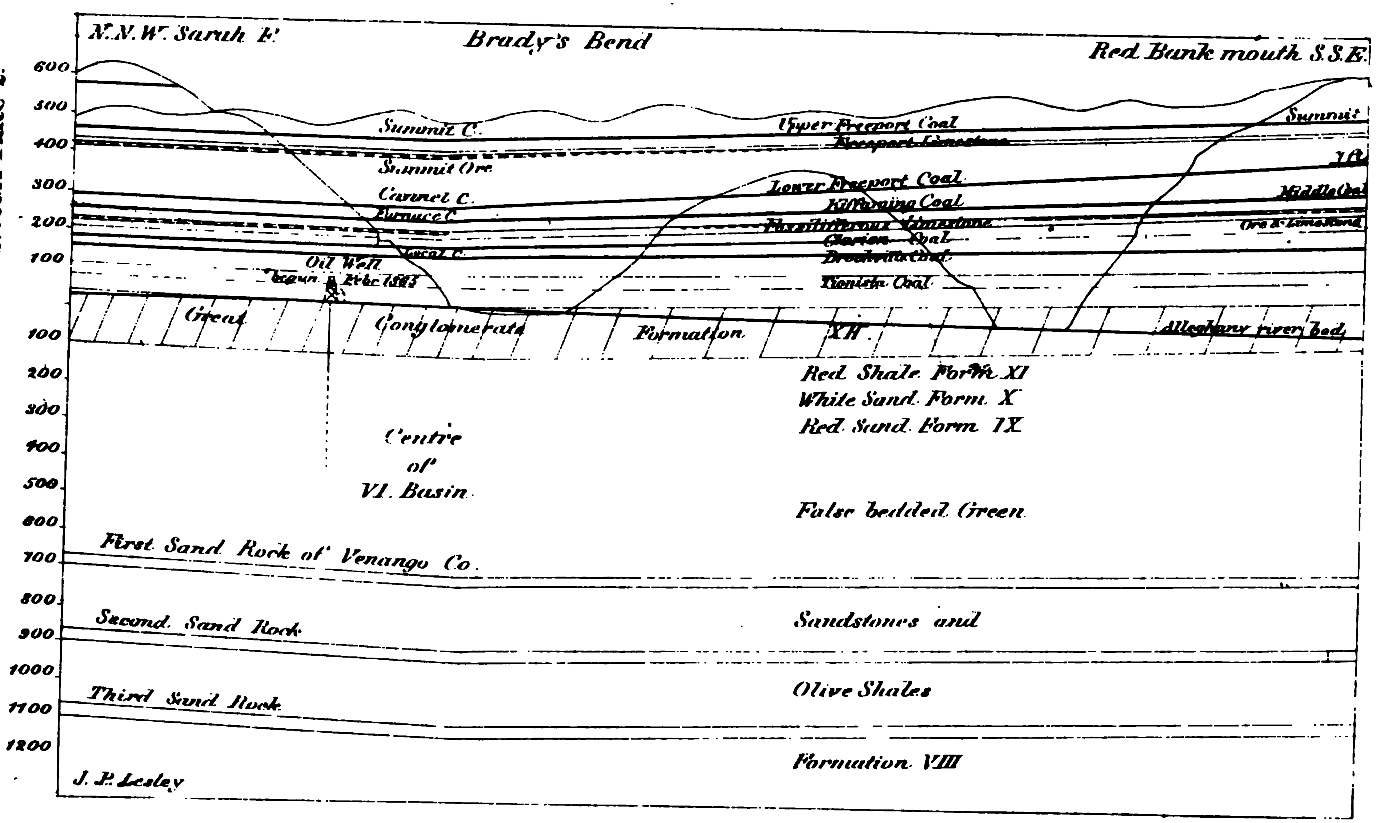
Coal, ''8; black slate, ''20; black limestone, ''20; black slate, 3; dark limestone, 1;	8
Slate, blue, 5''8; limestone, 1;	7
Sandrock, hard, 5''4,	5 = 146
Sand slate, blue, 40; sandrock, blue, soft, 8; hard, 12; hard and black, 18; dark blue, 10 (*gas vein struck at* 229''2, *strong*); coarse-grained, blue, soft, 1; blue and shaly, some black specks, 29,	118 = 259
Slate, hard, blue, rocky, 9; soft, blue (some black), 26,	35 = 294
Sandrock, dark blue, hard,	4
Slates, blue, brownish, and black, some like hard coal,	28
Slate, blue mixed with limestone,	2
Limestone, hard, free, with some sand,	5 = 333
Slate, blue, 4; *red, like kiel,* 14; soft blue (soapstone), 5; dark, some sandy, 11;	34 = 367
Limestone, black, mixed with ore,	1
Slate, dark blue, sandy,	2
Coal, ''16,	1
Slates, blue, some sandy, 37''8; blue and *red,* 2; *red kiel,* soft, 15; blue, becoming sandy downwards, with some hard layers, 11; and *some salt water* at 430 (at 428 hard shells, resembling white flint),	66 = 437
Slate, sandy, hard, blue,	16
Sandrock, soft, *almost black,* 8; close-grained, hard, blue and black, 23; very hard, blue (the hardest yet struck in the well), 4; *salt water increasing gradually from* 465 *to* 475 *feet,*	35 = 488
Slates, blue and black, with two thin layers of hard sand, 12; alternations of slates and sandrocks, 15; sandrock, blue, with hard shells, 6;	33 = 521

This should bring us nearly to the Freeport Series, or top of the Lower Coal Measures. The hard "shells," or crusts of white flint, found at different depths in this, and many other wells, and broken by the auger-bits only with extreme difficulty, are deserving of particular investigation. They seem to form impervious sheets of precipitated silica, effectual barriers against any general movement, upwards or downwards, of the underground drainage. The red clays (kiel) at 347 and 417, are the two "Red Bands of the Barren Measures." The coal at 370 lies between them; and its place is in the hillside at Pittsburg, not far above the mouth of the Manchester Well, last given.

By a combination of these four records, therefore, we have a complete section of strata extending from the Great Pittsburg Coal-bed down through the Barren Measures, Lower Coal Measures, Great Conglomerate, No. XI or Lowest Coal Measures, Sub-carboniferous Limestone, No. X sandstone, No. IX red shale, and the Devonian shales and soft oil-bearing sandstones of No. VIII.

J. P. Lesley

Pro A. P. S. Vol. X Plate 2.



PETROLEUM VEIN

IN

NORTHWESTERN VIRGINIA.

J. P. LESLEY.

May, 1863.

Professor Lesley communicated a notice of a remarkable coal mine or Asphalt vein, cutting the horizontal Coal-measures of Wood County, Western Virginia.

Mr. Lesley said, that through the kindness of R. H. Gratz, Esq., of Philadelphia, a descriptive letter and a map had been submitted to him, which exhibited geological facts of more than ordinary interest to those who are studying the origin of the rock-oil deposits of the West. This letter agrees with previously received, but vague, reports of a true vein of bituminous coal or bitumen. The curious points of the case require careful investigation; but there seems to be no good reason to doubt the essential correctness of the statement.

The mine is situated on a four hundred acre tract of woodland (oak, elm, maple, walnut, &c.), the position of which, in relation to the rivers and railroad of the neighborhood, will be best shown by the accompanying map. Plate III. It may be well to premise a few words about the coal-measure region in the heart of which it lies.

By referring to any map of all Virginia, it will appear that the North and South Branches of Hughes River unite and flow into the Little Kanawha about thirteen miles (in a direct line) above its junction with the Ohio at Parkersburg. The mine itself is somewhat over twenty miles (in an air line) southeast of Parkersburg, and a little under eight miles in an air line, south 4° west (both true and magnetic), from the bridge of the Parkersburg Branch of the Baltimore and Ohio Railroad over the North Branch of Hughes River.

Two peculiarities mark this "coal vein." 1. It is vertical, while all the stratification of the country is nearly horizontal; and strikes S. 78° W. (N. 78° E.), whereas the strike of the country is S. 35° to 40° W. (N. 35° to 40° E.) 2. It is a solid bitumen-vein rather than a coal-bed.

1. The country of the neighborhood is that of the central part of the great synclinal, which crosses the Ohio below Pittsburg, and stretches down through Western Virginia parallel to the Ohio River, into Eastern Kentucky. Across this broad and flat synclinal of coal-measure rocks there flow from southeast to northwest, to fall into the Ohio successively, beginning at the north, the branches of the Little Kanawha, of the Great Kanawha, the Guyandot, the forked branches of the Great Sandy, (and then in Kentucky) the headwaters of the Kentucky, the headwaters of the Cumberland, and finally in Tennessee, the headwaters of the Caney. All these fan-shaped water-basins have their highest or southeastern limit defined

by the strike (N. E. and S. W.) of the more upturned rocks of the southeastern side of the synclinal. With the exception of the Great Kanawha main stream, a line drawn along so as just to touch the extreme tips of all the outermost twigs of these water-trees, will give the southeastern limit of the great Alleghany Mountain or Cumberland Mountain coal area. Their waters collect in flowing northwest, break through the central measures and higher coals of the synclinal, and either join the Ohio (which flows along the depression between the upper and lower coal systems of the True Carboniferous), or the Kentucky and Cumberland Rivers further south.

From this short description it may be inferred, and it is a correct inference, that this belt of synclinal, is in great measure an irreclaimable mountain wilderness; a labyrinth of narrow hog-back ridges and steep, deep, winding vales, providing spaces for agriculture only along the narrow margins of the principal streams, and at here and there a little upland plain, caught in between the head-waters of half a dozen fan-shaped systems of drainage; but all the rest covered with an everlasting forest, folding over the furrowed face of the earth. The region consists in fact of myriads of secluded glens, surrounded by stair-like cliffs from four to eight hundred feet in height, and separated by spiculæ of mountain, which shoot out from the more central water-divides, like crystals of ice over the surface of a pool. The extremely tortuous course of the principal streams is illustrated by the map. They do not flow from side to side of wide, flat valleys, but around sharp mountain prongs, which point across towards opposite open ravines or valleys of considerable length. These prongs descend from the dividing high lands, like the spurs of the Pyrenees from the central ridge, but in long steps, the strata being nearly horizontal, and each sandrock in the descending order carrying the nose out further than the one above it. Narrow terraces carry the outcrops of the long steps of the nose, round each side of the prong along the steep side of the valley.

The coal-beds pass horizontally through the pronglike ridges from valley to valley. Some of these ridges run as narrow on top and as regular as railroad embankments, for three or four miles, and in nearly straight lines, between equally straight vales terminating bowl-shaped against some cross ridge.

It is across such vales and dividing ridges, that the Asphaltum vein of Wood County makes a straight course, A B upon the map, "2323 feet long, as at first measured, but since then traced in both directions still further, so that now it is known to extend more than two-thirds of a mile." Explorations beyond this line have failed to find it. Its outcrop, four feet ten inches thick, was discovered crossing a ravine fifty feet wide at the bottom, and rising on each side with slopes of nearly forty-five degrees. On one of these hillsides at a height of ninety feet, the outcrop showed the same thickness, but at a height of one hundred and eighty-five feet, it was found to be but two feet six inches thick. It is not certain that this diminution is in a vertical direction; it may be lateral; for the slope between the ninety and the hundred and eighty-five feet levels is more gradual, especially upon the western side.

In the bottom of the ravine, a vertical shaft was sunk to a depth of thirty-four feet upon the vein, which continued uniformly four feet ten inches thick, the asphaltum being filled in, pure and clean, without the least admixture of earthy or foreign ingredients, between the smooth and almost perfectly vertical walls of yellowish-greenish sandstone, lying in horizontal layers, through which this gash or fault was once no doubt an open fissure, communicating with some reservoir of coal oil, which still, it may be, lies beneath it undisturbed. The most interesting part of the phenomenon for structural geologists is this gash.

2. The substance which fills this gash-fault in the coal-measures of Northwestern Virginia, resembles the glossiest, fattest caking coals, and has a decidedly prismatic structure; breaks up into pencils, with flat, lustrous faces and sharp edges, but the faces not set at any fixed angles to each other; so that the effect upon the eye is rather that of a fibrous than of a prismatic structure. At the same time there is not the slightest appearance of layers, but the aspect of complete uniformity or homogeneity. Pieces are taken out, it seems, a foot in diameter; and that portion of one of these pieces which I have, shows a plain face on one side, as if it had encountered one of the walls, and is covered with a delicate film of a dead black substance like charcoal dust, which is probably the dust of the vein substance itself.

"Pieces lying at the surface of the ground are said to yield as much oil as specimens taken out six or eight feet down. By the ordinary dry distillation, the substance is reported to yield as much oil as the Albert coal. By a different process, the first and only trial, at which 600 pounds in one charge was used, 44½ gallons of superior oil was obtained. Retorts are now upon the ground."

By an assay made by Mr. B. S. Lyman, of Philadelphia (the amount of hydrocarbon soluble in benzole being about one-half of the whole) the volatile matter (mean of two assays) was 47.11 per cent., Coke (52.71, 53.07) 52.89; Ash (1.65, 1.81) 1.73.

There seems to be no escape from the conclusion that the substance filling this vertical vein is a product of the gradual oxidation of coal oil once filling the open fissure. It is not impossible therefore that the lower regions of the fissure are still filled with liquid oil; and that we may see in this instance an illustration of the condition of things far beneath the surface of the coal oil regions of Western Pennsylvania and Eastern Ohio. The vast quantities of oil delivered by the flowing, the blowing, and the spouting wells require fissures of this kind, either never opened up clear to the surface, or else once opened and now reclosed, or else filled in with detritus. The different depths at which closely neighboring wells begin to spout or to flow, oblige us to imagine similar fissures at oblique angles. If Sterry Hunt's hypothesis be accepted, that the Corniferous Limestone is the mother rock of the oil, such fissures become still more needful to bring the oil to the surface, from the vast depths at which the Corniferous Limestone underlies the True Coal-measures.

Vanuxem first described the films and buttons of "anthracite," as he called it, with and in the quartz crystals of the Calciferous Sandrock of New York, at the base of the Silurian system. Mr. Hunt describes the veins and fissures of all the limestone, shale, and sandstone members of the great Quebec Group (which is the enlarged equivalent of the Calciferous in New England and Canada) as frequently either lined or filled with a similar substance. Sometimes the varnish lining has cracked in shrinking; sometimes botryoidal masses of it have been left; sometimes hundreds of pounds of it are packed away solid in the crevices. In one exceedingly instructive case the vein of bitumen, inclosed in walls of rock crystal, is itself cut by thin seams of quartz.*

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* Hunt in Amer. Journal, March, 1863, p. 163. The force of the argument deducible from this fact, against the igneous, and in favor of the aqueous production of our quartz veins, will be felt at a glance. I cannot but express my surprise that Sir David Brewster should continue to claim as an argument for the igneous theory, the presence of two different elastic hydrocarbon fluids in cavities in topaz, beryl, and diamond, especially in regard to the permanent compression they have effected in the molecular structure of the walls of the cavities, as detected by polarized light. (Trans. R. S. Edinb., XXIII, i.) Yet M. Fournet supports his argument. (Comptes-rendus, LI, p. 42, LIII, pp. 83, 610; Geol. Lyonnaise, Lyons, 1861, pp. 533, 715, quoted by Sir David Brewster.) While M. Elie de Beaumont rests for its refutation on the volatility of the fluids, and the frequency of fluid-cavities in all quartz gangue rock. (Comptes-rendus, LIII, p. 83.) Sir David Brewster says that M. Fournet "has removed this difficulty" (Geol. Lyon., p. 536), but does not say how.

In these older instances of bitumen veins, we see small prototypes of the large vein under consideration.

The point of the phenomenon most interesting to structural geologists is this: Two opposite deductions are possible from the facts as made known, on the one side in favor of the vast antiquity of the coal oil, and on the other side in favor of the recent denudation of the surface. If we have in this vein a deposit of coal oil hardened by time and the absorption of oxygen, it is certain that the cutting out of the ravines across which it lies, must have taken place subsequently; for the outcrop rises to a height of nearly two hundred feet on each side of the bottom of the ravine in which the shaft is sunk. I do not learn from the report whether detached blocks or pieces of the bitumen occur upon the surface, or in the alluvium of the vale below the crossing of the vein. But that is of no consequence to the principle. The valleys which it crosses must be younger than the vein, if the vein was filled with fluid oil. Hunt shows plainly (see Sill. Journ., March, 1863, p. 167), that the oil which fills the fossil casts of particular exceptional strata in the Lower Devonian Formation (as in Bertee Township on the Niagara River opposite Buffalo), must be an original deposit, and not a subsequent infiltration or exudation, inasmuch as it has lined with oxidized bitumen the cavities of the fossil casts in this stratum, and not those in similar strata above and below.

All that we know of the grooving of the surface of our palæozoic areas consents to the great antiquity of the action, whatever that action may have been. To demonstrate the antiquity of the Corniferous coal oil, is merely to give more room for the antiquity of the oil. Yet, the denudation, however ancient we may make it, must still be kept more modern than the antecedent formation of the coal oil and its change to bitumen.

The date of the formation of the oil may be placed anywhere beyond the close of the Palæozoic era, even as far back as the beginning of the Devonian, or even in Lower Silurian times; since the Quebec Group is also the home of oil. The denudation of the surface of the coal areas cannot of course be put back beyond the uplift of that area into the air.

There remain two hypotheses for dating this denudation. One class of geologists, the Cataclysmists, give the date of the uplift as the date of the denudation; make the two phenomena related and dependent parts of one great action. The other class, the Secularists, regard the present face of the country as but the latest phase of an infinite series, beginning at the uplift and still in progress. An intermediate view, held perhaps by some eclectics, supposes a succession of denuding actions of unknown force and indefinite number.

As to the Appalachian region of the United States, I think that the principal special objection to the theory of one cataclysm (apart from general considerations) has not been mentioned, or at least clearly stated. And yet it seems to me of great force. It is a deduction from the fact that the estuary bed of the New Red deposit, taken as a grand whole, can hardly be regarded otherwise than as a part of the Post Carboniferous denuded surface, and therefore subsequently formed to the great cataclysm supposed by that theory to have produced that surface. For the surface of the New Red is eroded exactly in the style, and in the direction of, and in entire harmony with the erosion of the surface of the Coal; which of course would make the supposed cataclysm subsequent to both. Two cataclysms being therefore required, a new difficulty appears.

Supposing the first cataclysm to have eroded the palæozoic areas, so that the deepest valleys of erosion nearest the Atlantic seaboard could be filled in with New Red deposits, why were these deposits restricted to the New Red estuaries, so well known as to need no description here? Every one is aware that New Red is nowhere seen behind the range of the South Mountain or Blue Ridge. Yet there are plenty of gaps wide and deep enough to let it through. If it had ever been deposited in the great Lower Silurian Valley behind that range, no cataclysm can be supposed to have acted with such consummate skill and completeness, that not a hillock or corner bit should have remained to tell the story of where its outspread masses had originally lain.

If now, to meet this difficulty, the Cataclysmist brings down the date of his first agency to Post Secondary days, and imagines the New Red rocks to have been excluded from the Great Valley because in fact, no such valley, and no gaps leading into it, had as yet been formed, he not only encounters the old difficulty of providing its estuary bed for the New Red, but in addition to that, the awkward statement that the gigantic anticlinals of the Palæozoic age, once made, remained, uplifting their more than Andean or Himalayan masses in the sky, (with all the climatal consequences of such a supposition), during all the ages through which the so-called Permian of Kansas, and the New Red, and the so-called Oolite of the Atlantic seaboard, were depositing their layers.

And when he has settled all this properly, the discussion will reopen upon him in the same form anew, so soon as the denudation of the Cretaceous and Tertiary surfaces come to be regarded as in like manner in harmony with those of older dates.

At Cornwall, six miles south of Lebanon, hills of New Red Sandstone, three, four, and perhaps five hundred feet high, stand, looking in upon the great Silurian plain, like Peris at the gates of a Paradise they cannot enter. If along this line a *fault* has in fact carried the New Red down to the present level of the Silurian plain, the denudation of the two surfaces is nevertheless so far one phenomenon, that in its present condition it is to be explained by reference to actions subsequent to the deposit of the Conglomerate, or uppermost New Red layer, the so-called Potomac marble. But the hypothesis of a fault along the south base of the South Mountain is a pure fiction of embarrassment. If it existed anywhere, it must extend several hundred miles, and be approximately a straight line. The most cursory glance at the geological map of Pennsylvania will satisfy any one that no such fault exists. The succession of spurs of the mountain range forbids it. The gophered edge of the New Red on the Lancaster County limestone forbids it, and shows how entirely superficial the New Red is. No river section shows the fault. It is a pure fiction. The northwest dip of the New Red against the Azoic mountain range is still a problem to be solved.

The hypothesis of suboceanic erosion, contended against by the geologists of the United States almost from the beginning, is fast losing, if it has not lost altogether its hold upon the European mind. The conviction is well established, which we freely expressed years ago, that the ocean is a builder and not a leveller. Like the quietistic and subjective letter M, which was its symbol in ancient literature, the main, the murmuring Typhon, has always been the absorber, and the mother of multitudes. While the fringe of foaming breakers, the Herculean Hydra, and in fact all river water, the rushing and hissing Typhon, of which the letter S was symbolic, has always been the destroyer, the enemy of the established, the ravager of the surface. It was upon this basis that some *subaerial* cataclysmic hypothesis like that of Professor Rogers came to be favored by those who knew the grandeur of the work which had been done by the denuding force whatever it was, among the palæozoic anticlinals of America; and who felt the perfect harmony which reigned over the whole expanse of the phenomenon, from the Tertiary seaboard of the Atlantic and the Gulf, past the beds of the great freshwater Devonian and Silurian lakes, to the original shores of the Laurentian Continent.

We cannot regard, therefore, without some natural chagrin, the latest treatment of the subject by Professor Tyndale and Professor Ramsay, of England; for these accomplished observers not only take up our own old views with all the empressement of new discoveries, but make what seems to us the very absurd attempt to carry the petty energies of mountain floods and local glaciers up to the work of excavating, not merely lakes like those of Como, Constance, and Geneva, but such seas as Lake Huron and Lake Superior. It is gratifying, however, to see that such views can be refuted by European observers, who have never encountered the phenomenal problems of America. The impossibility that a moving glacier after descending to sea level, should excavate the bed of a lake, and continue to move up and over its farther end, even taking the smallest Alpine lake known for an example, is admirably demonstrated by Mr. Ball in the February number of the London, Edinburgh, and Dublin Philosophical Magazine for 1863. If this be not possible for the tarns among the valleys where glaciers are at home, how can it be possible for lakes and seas, where the existence of glaciers at any epoch is a theory? And how reckless of all consequences must that theory be, which reads an incantation to these icy demons, to accomplish the symmetrical erosion of a triangular area of earth-surface a thousand miles on each side long, the southern angle of which touches the parallel of 33°!.

Professor Ramsay calls attention to the remarkable fact that the lakes of Europe and America seem to be confined to the scratched and grooved portion of the hemisphere, and that they are not found further south than the drift, except in Alpine, that is to say, in glacial regions. This is a coincidence, indeed, which ought to harmonize the two phenomena under some theory; but not necessarily subordinate the one to the other as effect and cause. I have no satisfactory explanation to give for the coincidence. The special reasons for the existence of each separate lake can be easily pointed out. The damming back of the waters of the New York Devonian lakes, including Erie and Huron, are due to the gentle northward rise of their floor-rock. Lakes in the same soft Devonian measures, are numerous along the valley of Pennsylvania, at the foot of the Alleghany Mountain, but only where the measures are gently inclined. Lakes disappear from the map as the eye passes southeastward over the more upturned regions. Steepness of dip is hostile to deep excavation.

The reverse is true of erosion above water-level. Steepness of dip is favorable to aerial disintegration, to the dissection of stratification, to the subdivision of one massif into several, and of one hillock into many; hence to the general degradation of the surface under air. But under water the reverse is true.

In the Laurentian and Huronian, Scandinavian or Azoic regions of the North, where distortion and plication have revelled from the beginning to reduce things to anarchy, and where alternate potash rocks and limestones form the boldest contrast of endurance and decay, lakes abound. A clean, smooth drainage system, worked out so completely (without stating the agency) as to leave no holes, nor cul de sacs pointing in the wrong direction, nor crooked lakes, is possible only when the stratification is clean and in good order, cutting equally and smoothly in all directions according to the force, and permitting the law of compensation to have free course in the establishment of a common and gently declining niveau of reference to water-level. But any conceivable erosive agency, cataclysmic or secular, must encounter a million contretemps, in smoothing off its work over a country like Canada, where no outcrop runs far without doubling like a hare. Sir William Logan has shown that the crooked lakes and lake-like rivers of that country conform to the plications of the primary limestone belts.

Mr. Ball's own hypothesis of an original fault structure for the lake system of the Alps is not new, and is open to as much objection on other grounds, as the theory of Professor Ramsay which he overthrows. If applied to the Devonian lake system of New York and Pennsylvania, and therefore, of course, to the thorough-cut valley system of the Carboniferous plateau of the Alleghany Mountains of Northern Pennsylvania, it will not find a fact to stand upon. Not a trace of fault structure is to be seen over all that immense region; yet the erosion is in straight lines, north and south, and from five hundred to a thousand feet deep. Also not a trace of *original* glacial action can be found. Diluvial striæ are rare; moraines and taluses are wanting. Not one has yet been recorded, if any exist, nor have I ever seen throughout that region, any resemblance to one which did not resolve itself on examination into a barrier outcrop, slightly masked by soil or local drift; and even instances of this kind are rare.

On the other hand, throughout that whole region, the Lyellist can find no evidence of a slow wear and tear through the ages. The region is swept too clean for that. There are no piles of detritus, no cones at the mouths of ravines, no plains of sand and clay, no deltas at the embouchures of streams and heads of lakes, such as, in the Auvergne, and in the Alps and Pyrenees, impress the traveller with an instantaneous and irresistible conviction of slow wear and tear. On the contrary, the walls of the valleys, high as they are, are vertical bluffs, alternating with taluses of angular blocks fallen from them; the bottoms of the valleys are clean; the lakes have steep shores, and the plains are covered with the disintegration of their own rocks. Everything one sees tells one story, and that the story of a cataclysm which, at one sweep, accomplished valleys, plains, and lakes, leaving next to nothing for all coming time to do, but to protect the surface with vegetation, and to send an annual contribution of the meanest value by the rivers to the sea.

Two systems of valleys characterize the result, as we now study it. One parallel with the coast, and produced by the sweeping away of the tops of anticlinals from one to twenty miles wide and miles in height; the other a transverse system of river bottoms, sunk some few feet or yards below the longitudinal valley which they cross, and of deep, clean, straight gaps through the bounding mountains. It is demonstrable that these two systems are but two parts of one, and owe their origin to the same agency, and at essentially the same time. The peculiar relationship of the rivers to the gaps is sufficient of itself to prove this. Not a fault has been demonstrated in any of these gaps. One fault transverse to the Tussey Mountain occurs *near* one gap, that of the Juniata, and as if, by its loneliness and excentric position, for the express purpose of excepting to such a theory, if at any time one should be presented. It is not until the geologist has passed through the whole region, and has reached its southeastern limit, that he suspects a faulty gap. The Kittatinny or North Mountain is said to be faulted at the Delaware Water Gap, and at the Susquehanna; but so the Sharp Mountain was said to be faulted at the Swatara Gap, until careful instrumental work proved that the coal-beds on each side of the gap were not a hair's breadth out of line. A fault at the Susquehanna is evidently absent, for the very outcrops of the different sandrocks can be traced, at low water, from side to side. And the fault at the Delaware Water Gap is, I believe, nothing but an effect of perspective upon the eye, produced by the inclined lines of cliff, unsymmetrically wrought out on the two sides of the gap, because the cutting force worked in a curve, produced by the presence of the expiring Red Hill anticlinal on its northern slope.

No. The excavation of the Appalachian surface has not been determined by transverse faults; but entirely by longitudinal flexures; and has not been accomplished by glaciers; nor by rain and river water; still less *sub oceano*. By what then? I think much must be discovered before the question can be answered, if we reject subaerial deluge action. What for example do we know yet of the internal structure of those deep diluvions or alluvions which occur in our transverse river-bottoms, where they cross the longitudinal valleys of Devonian olive shale? They seem to be ancient lakes, excavated at the time the topography of the valleys and mountains was determined, and filled with river trash. As they occur in the transverse river valleys, they seem to own the rivers for progenitors. But being in line with the gaps, the occupation of them by the rivers seems, on the contrary, to be as fortuitous as the river-occupation of the gaps. Moreover, the present rivers are evidently the degenerate representatives of grander floods, and the silt of these depressions, judging by the surface, is of too gross and hasty a nature for collection by less than such original deluges. But supposing this also to be a fancy, what relation does the glacial hypothesis, which presumes to annul the necessity for a cataclysmic eroding agent, propose to bear to parallels of latitude?

Wherein does the valley of the New River or Kanawha differ from that of the Susquehanna or Delaware, except in having no New York corals or Canada syenites among its pebbles. In every structural feature they are alike; and like the valley of the Tennessee in Alabama. There is no change in the height or constitution or form of the mountain plateau through which they cut. There is no change in the range to the southeast of them which can affect the question; for the Black Mountains of North Carolina, even if liable to suspicion as glacier-bearers, are far enough removed from the New River on the north, and the Tennessee on the south, to be of no account in this discussion. Is the glacial hypothesis prepared to defend its claims in Middle Alabama under the parallel of 33°? If not, then it has no claims to any feature of the Catskill Mountains under the parallel of 43°, except their scratches; to which, so far as the genesis of mountains and valleys is concerned, it is quite welcome. Yet precisely this bonbon Professor Ramsay refuses it; for he maintains (against Dana), that the striæ at the Catskill Mountain House were made by icebergs floating down the Hudson estuary, and not at all by glaciers. There is a disposition manifested of late among the American geologists, of the New England school, to fill each of the great valleys of the North with a great glacier of its own, naming them the Penobscot Glacier, the Connecticut Glacier, the Hudson Glacier, the Mohawk Glacier, the Susquehanna Glacier, &c. In view of Kane and Hayes's discoveries of the present state of things in Greenland, and for easy accounting not only for such groups of east and west and north and south striæ as appear at Cherry Valley, the Catskill House, and Wilkesbarre, but also for those which cross the polished summits of our highest mountain tops, such as the Penobscot Knob which looks down upon the valley of Wyoming, there is not the same objection felt now as was at first expressed against the Agassizan cope of ice for the hemisphere. President Hitchcock finds its reliquial glaciers in the valleys of Hampshire and Berkshire, and Professor Dana explains the absence of moraines now by the absence of any aiguilles to overhang and shed their stone-slides upon the back, or upon the edges of its subdivided streams.

The thus admitted absence of moraines, and the excuse advanced for it, return us unexpectedly to the starting-point of the discussion, the question. Could ice have fashioned our topography? No one doubts its ability to scratch and groove and polish. Can it excavate? And if it can, what is the limit of its excavating power? Leaving the glacialists of the fixed-ice school and the floating-ice school to settle between them the force, frequency, direction, and exact *modus operandi* of striation, quite sure that they will at least agree on the *date* of the phenomenon *as very recent*, we are left at liberty to revert to those more remote days, when the broad-backed anticlinals rose into the sky higher than any Alpine aiguilles or Andean volcanic cones; to speculate on, 1, Whether they were unbroken vaults; or split along their axes; 2. If split, whether split completely down to water-level, or how far; 3. Whether glaciers could have been then formed at all; 4. Whether, if formed, they could excavate a valley five or ten miles deep into the heart of an unbroken anticlinal; or 5, Do more than polish the central gorge, if the anticlinal were broken; 6. How such a central glacier could escape from such a gorge sideways, or in any direction but endwise, at the limits of the crack; or 7. Fail to leave high walls, alpine ranges, peaks, aiguilles, and moraines behind it when it disappeared.

Surely the glacialist must startle back from such an incredible picture. The great obstacle in the way of topographical science among geologists, has been an innocent ignorance of the titanic postulates upon the ground; and therefore, an inability to reconstruct in imagination the awful vaults of rock which have been removed from over at least fifty thousand square miles of the surface of the United States, merely along the one belt of the Appalachian Mountains, between the great coal area and the Blue Ridge range. What has removed these massifs? The excavation of a hundred Lake Superiors to the depth of two thousand feet would not present the same difficulties. Either a cataclysmic subaerial deluge mighty enough to do the work, or a series of such deluges following each other until the work was done, or the atmospheric agencies at work on every square inch of the whole area for almost an infinity of ages,—one or other of these three must be the accepted force. Ice may come in for its share of the byplay, at various and very early times (as Ramsay has made probable in Shropshire) as well as in the last days of its glory, the stamp of which we see left upon our outcrop surfaces; but to make it the initial agency of such erosion is absurd. The power of ice could no more have swept those symmetrical palæozoic arches into the Atlantic, than a child could have flown to Loretto with its church. But whatever did accomplish that work, did it all; established the general register of heights; made every mountain a consistent part of the harmonious whole; worked out all the Lower Silurian valleys precisely on one pattern; excavated every Devonian lake from Harvey's Pond to Lake Huron alike; and cut to the same contour the subcarboniferous cliffs along the whole line from the icy Delaware to the sunny Alabama.

Of the seven or more chief points of speculation cited above, that of the split anticlinal is of course the most important. The admirable illustrations of the Austrian survey, which Haidinger and his noble coadjutors have been giving us for several years, repeat with variations all the curiosities of our Appalachian anticlinal structure, which were prepared for publication twenty years ago by the State Survey of Pennsylvania. But being chiefly sections of younger rocks than ours, the Austrian diagrams exhibit a more disturbed surface, so far as regards faults and slips, snapped anticlinals, upshoved synclinals, lapped folds, insertions or knife-edge intrusions of fragmentary strata, &c., while the main features are all the same. This may hereafter be adduced by some one as an evidence of the necessity of assigning quite a modern date to our contortions; inasmuch as disturbances, *relatively* as old (that is, occurring when the palæozoic rocks had as yet obtained no greater consistency and compactness than the newer secondaries or tertiaries of the Alps) ought to have dealt as hardly with those, as the Austrian subterranean forces have dealt with these. But that would be a hazardous conclusion; for the nature of the bottom on which they lie probably determines, more than any other determining cause, the amount of disturbance in the normal curves of an uplift. The lateral thrust of horizontal tertiaries over a ragged bed of already upturned secondaries, or of flat and soft kainozoic strata over an already formed palæozoic topography, cannot result in symmetrical anticlinals and synclinals; and the amount of hitch and catch below, and therefore of crack and shove above, must be proportional, (1) to the roughness of the old surface, and (2) to the thinness of the new formation. But in the case of the Appalachians, both these proportionals are in the lowest ratio: (1) The palæozoic mass is seven miles thick, and (2) It lies conformably on the "azoic," if not on the "hypazoic" surfaces, so far as we can see, or with local exceptions; and there is reason to believe that where this is not the case geologically, it is the case practically; for the Potsdam sandstone, Quebec group, Taconic system or Primal Formation (whichever name we prefer), probably lies upon an already planed off surface of Laurentian primaries. Hence the wonderful symmetry of the palæozoic vaults and basins, the almost total absence of faults (until one goes far south), and the infrequency and smallness of earthquakes.

Hence also the high probability that the anticlinals were unbroken at the crest. A broken anticlinal must, in ninety-nine cases in a hundred, develop a fault. In the south, a system of broken anticlinals have developed a magnificent system of parallel faults. If the symmetry of our northern anticlinals is the *first* argument against their being originally broken, the absence of faults is a *second*; a *third* is to be found in the many instances of unbroken small anticlinals, unbroken even when overturned and collapsed; a *fourth* is to be found in the absence of any trace of a break in the symmetrical end mountains, formed by the closing of the outcrop walls of an anticlinal valley at both ends of it; a *fifth* is to be found in the side gap structure, which universally accompanies and characterizes the anticlinal structure; a *sixth* is to be found in the total absence of lakes along the anticlinal axis; a *seventh* is to be found in the evident compensation for room lost by room gained along any given cross section.

At this last point I think lies the solution of the problem. A true section of the crust, transverse to the waved structure, would show a perfect compensation between the sum of the outside and inside curves of the side by side lying anticlinals and synclinals; such a compensation as would distribute the slip between the rock faces, or back-and-belly planes of the stratification, through the whole mass, and thereby reduce it at any given point to a minimum. This distribution of the slickensides movement, taken into connection with the crumpling up into subanticlinals, and the tongue-shaped crimpling of the softer measures inside of these*, must have relieved the strain upon the outside of the synclinals below and anticlinals above, and set quite aside the necessity for those yawning gaps which are supposed by many to have occurred along all the great anticlinal axes of the region. It may be safely taken for granted, that had such occurred on the upper side of the anticlinals, similar ones would have occurred on the under sides of the synclinals, of which we see no trace. That the slipping of stratum upon stratum has gone on everywhere is everywhere evident. The softer formations have been most injured by it, and are penetrated by crumplings when the harder strata have splintered and fissured. But, as a whole, the plicating energy must have acted with a steady evenness of thrust, which carried up the anticlinal waves of the crust unbroken, and in some cases to a height of between five and ten miles above the present surface level.

By what agency could these masses have been removed, without leaving Alpine ranges, with serrated summits and protuberant spurs? Can we imagine the Pyrenees to be reduced by ordinary atmospheric erosion to the condition of the Jura? Giving even infinite time, will the desired result be ever attained? On the other hand, given a homogeneous element with sufficient force, acting either by one or by repeated blows, the result as we now see it on the present ground was demonstrably certain to come from the conditions which we see to have existed on the former ground. No one will deny that water, if obtained in sufficient quantity at a sufficient velocity, would be such an agent. In the acknowledged instability of the crust of the earth, and in its acknowledged less stability in ancient times than now, we find the possibility, nay, we feel the certainty, that the oceans have at times been launched across the continents, and we need nothing more to satisfy all the conditions for an explanation of Appalachian topography.

Parts of a private letter from Leo Lesquereux, Esq., of Columbus, Ohio, were read respecting the fossil botany of the coal, and the publication of manuscript memoirs in preparation to illustrate it; and also respecting the character of the Millstone Grit or Subcarboniferous Conglomerate in the Far West. Of the first he says:

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* See Plate V for a few instances of this structure as yet unpublished. Many others, even more instructive, can be obtained in our various collieries. The western edge of the Broad Top basin is remarkable for the number, symmetry and regular sequence of these tongues; but they are common to all the anthracite basins. Fig. 5 is an accurate representation of one near Beaver Meadow.

> If it is finished according to my original plan, it should have at least one hundred and fifty plates. There is no fossil flora of the coal; that is, there is no work on the subject, where one can find figured and described all the species of any coal-field. All has been made by fragments. Brogniart's fossil flora is not half finished, and will not be continued. Lindley and Hutton have published plants of all the palæozoic rocks of England, but all is mixed there, and no part is complete. Göppert has all his published fossil plants disseminated through a number of books, of which no one contains a complete series. Now, for the fossil flora of our coal-measures, I would like to publish drawings and descriptions of all the species, even if these species are already known and published from the coal of Europe; for a double purpose: firstly, in order to enable the student to proceed in the study of our fossil plants without the cost and incumbrance of a large library, which is now impossible; and secondly, to show from the beginning of the vegetation of our earth, the remarkable similitude of American with European types, always broken by characters of dissimilarity as difficult to appreciate now, as they were at the epoch of the coal. . . . It is an entirely American and original work. . . . You well know that everything has been, so to say, put in my hand for such a work. After the Pennsylvania survey, I have had those of Kentucky, of Arkansas, of Illinois, Indiana, Ohio; this last on my own cost. All the best collections of fossil plants of the United States have been sent to me for examination and classification, and thus I have seen an immense number of specimens, without counting those which I have collected myself. Would it not be wrong to abandon and lose the result of a work of so many years, and the advantage of so fine an opportunity for study, and leave the work unfinished, merely because I do not know how or when it can be published? I will go through if I can, or as long as I can, and if the work is good, it will come out in some way, even if I am not more of this world. . . .
>
> I do not send you now the plates of the fossil plants of the Tertiary, ten in number. . . . All the Tertiary fossil plants that I have had under my examination, those of Mississippi, of Kentucky, and of Vancouver's Island, would make about fifteen plates. . . . Some questions of true scientific importance might

be discussed with their publication: 1st. The relation of the actual flora with that of the Tertiary. 2d. The comparative identity of typical forms both on the Pacific and Atlantic shores. By comparative identity I understand relation of the now living plants on both the Atlantic and the Pacific shore, with the fossil flora of the same country; the relation of the Vancouver Tertiary with the California flora, and the relation of the Tertiary of Mississippi, &c., with the Atlantic flora. Of course this does not indicate a relation of vegetation between both sides of the continent, either at the Tertiary epoch or now; on the contrary. 3d. The difference of flora of Europe and of America, at the epoch of the Tertiary, showing the separation of both continents. You know that Heer argues, on a supposed but unreal identity of typical forms at the Tertiary time, and concludes in favor of a Continental connection, either by an Atlantide, or something of this kind. 4th. The relation of forms of the Tertiary and Cretaceous floras, &c., &c. . . .

With this letter I send you two sections of the Arkansas conglomerate measures, and the underlying subcarboniferous measures. I am, indeed, very sorry that my sections were not made with more details and exact measurements; but I am not answerable for the deficiency. My assistant, Mr. Cox, had charge of the geological part of our explorations, and . . . we had for our measurements only an aneroid barometer, which, though pretty good, gave us only approximate altitudes.

The first general section, showing the true position of the coal in relation to the inferior strata, was taken fourteen miles southwest of Fayetteville, in Washington County, on the high waters of Middle Fork of White River.

	FEET.	INCHES.
1. Millstone grit in alternating beds of coarse, gritty sandstone, conglomerate hard sandstone with small pebbles, ferruginous hard bands, and soft shaly sandstone and shale, .	300	
2. Gray laminated shales passing at some places to ferruginous, very hard conglomerate. Shale band, . . .	2	
3. Coal, ...	1	6
4. Hard, black fire-clay full of stigmaria, passing at the base to clay-iron ore, ...	6	
5. Hard limestone with Encrinites, Terebratulæ, Archimedes, &c., &c. Upper Archimede limestone. It appears to be united with the lower bed sometimes, and then thickens to 20 feet, ...	10	
6. Blue soft shales with pebbles of carbonate of iron, . .	20	
7. Shaly sandstone (gray metal of the miners), . . .	30	

8. Hard coarse limestone, with great abundance of the same fossils as the upper one, ...	10
9. Cherty limestone, mostly hard silex, ...	6
10. Coarse sandstone with plants, Stigmaria, Sigillaria, Lepidodendron, &c.,*	60
11. Coarse limestone, lower Archimedes bed or middle bed?	30
12. Coarse and soft brown sandstone with a great number of fossil shells (Knob sandstone?)	100
13. Hard black limestones with fossils, ...	40
14. Black and yellow shales with carbonate of iron (Devonian?)	40

The second section is that of the Millstone Grit, and is taken from the base to the top of the Horsehead Mountain, a part of the Boston Mountain in Johnson County. It is,

	FEET.	INCHES.
1. Calcareous shales and argillous sandstone, containing a quantity of fossil shells. The top of the hill is covered, and apparently has a stratum of conglomerate; at least loose pieces of conglomerate are found above the exposed fossiliferous shaly sandstone. From top of hill down, .	30	
2. Compact and shaly sandstones in alternating beds, . .	120	
3. Massive, coarse, gritty sandstone, ...	80	
4. Shaly sandstone, sometimes in banks, covered with vermicular impressions, and cut by hard bands (ferruginous shales), ...	120	
5. Coarse, gritty sandstone, with conglomerate at the upper part. The pebbles are small, not larger than a bean, .	20	
6. Hard, compact, gritty sandstone in banks, alternating with shales and shaly sandstone, ...	520	
7. Red, yellow, and soft ferruginous shales and shaly sandstone, ...	150	
8. Gray, hard, micaceous shales, mixed with pebbles of carbonate of iron, and having fossil plants especially near the base, ... from 10 to	70	
(These shales at Horsehead have at some banks only six feet, at others as high as seventy feet. They pass to sandstone at the upper part.)		
9. Black, soft, earthy shales, ...	1	
10. Coal, ... 10 inches to	1	6
11. Fireclay, black, hard, full of stigmaria to level of the creeks.		

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* In Illinois, the sandstone has the same plants, and is overlaid by one bed only of the Archimedes limestone. In Indiana, where this sandstone is absent, it is replaced by a thin bed of coal just under the upper Archimedes.

Remarks concerning the nature and variety of the Millstone Grit of Arkansas, are noted many times in my diary. Thus, I read: Passing the hills or divide between the affluents of White River, I find the Millstone Grit of still more varied appearance. Sometimes it is a coarse, hard sandstone, a compound of fine grains of quartz, true millstone grit very hard, and in thick banks. These are separated or underlaid by soft, easily disintegrated, shaly sandstone, and thus they break in large massive banks or pieces thrown down along the slopes of the hills, or in the narrow valleys. Sometimes the same formation is mostly a compound of shaly sandstone, alternating with ferruginous shales, separated by thin beds of clay iron ore, or even of hard fireclay, without any trace of conglomerate. Sometimes the sandstone becomes black, ferruginous, and is here and there cut by a narrow *streak* of conglomerate, whose quartz pebbles are rarely larger than a small hazel-nut, generally much smaller. The Millstone Grit-measures are far more persistent in their thickness in Arkansas than in the East, and as the top of it has not been seen anywhere, the highest mountains being too low, it may be supposed that its thickness is greater than it has been measured at Horsehead Mountain.

Of course, though the variety of appearance and the great thickness of the Millstone Grit of Arkansas can be compared with some parts of the coal-measures of Nova Scotia, referred by geologists of that State to true coal-measures, we cannot conclude an identity of formations. From what you published in the Proceedings of the Society, I agree with you, and readily believe that the Nova Scotian basin is a separated member of our great American coal-fields. The flora of both the Canadian and the United States coal-fields is apparently the same. At least, of all the plants published by Bunbury, too few in number, indeed, to permit a satisfactory comparison, there is now no one that has not been found in our coal-fields. *Odontopteris cuneata*, Bunb., was for many years unknown in our coal-measures, but I have found it in plenty two years ago at Murphysboro', Illinois. This and a few other of Bunbury's species have not been found in Europe. But contrary to our opinion, we have these facts, that the anthracite basin of Pennsylvania is from all appearance the shores of a coal-basin. That Dawson finds in Canada an abundance of fossil coniferous wood; that the English naturalists assert that such wood is also in plenty in the coal-measures of England, while I can find none in ours; that also from Dana's assertion, the fauna of the coal-measures of Nova Scotia is rather related to that of England than to ours. If it is so, we would have on our continent an anomaly of relation contradicted by what we know from the other formations. Good and long palæontological researches may help to settle the question. . . . .

It is certain that our coal-measures are increasing in thickness eastward, especially for the sandstone and the shale strata. Admitting, if not a continuity, at least a contemporaneity of formation under the same influences, and a continuation of increase of thickness in the same direction and the same proportion, this would already give us many hundred feet of difference for Canada. I understand moreover, that a shore formation of the coal has been necessarily subjected to a great many local variations, which could not reach an inland one. It is clear that the invasion of the sea, bearing with it sand and other materials, could not always penetrate the inland part of the basin, and cover the whole of it. This accounts for the multiplication of strata, and the dividing of coal strata into thin and numerous seams. Of course, if such divisions did happen on the shores, while the internal part of the basin continued in the same state of a continual peat growing, boggy marshes, the vegetation of these partial coal-seams cannot be variable. So local vegetation is always affected or directed by the general one, and the difference of vegetation of our coal strata becomes especially evident, after such cataclysms or such changes of level under the influence of which the whole extent of the coal-measures was covered with deposits, brought by water or formed under it, viz., sandstone or limestone.

It is therefore evident, that even if it was based on well ascertained facts, the sixth objection of Professor Dawson would be of little importance, especially in its application to our coal-measures. But I find it extraordinary to say the least, when compared to other assertions of the same author. In his last valuable paper on the flora of the Devonian period (Quarterly Journal, November, 1862), he says, page 328: "Some species which appear early in the Devonian period, continue to its close without entering the Carboniferous; and the great majority of the species, even of the Upper Devonian, do not reappear in the Carboniferous period, but a few species extend from the Upper Devonian into the Lower Carboniferous, and thus establish a real passage from the earlier to the later flora. The connection thus established between the Upper Devonian and the Lower Carboniferous, is much less intimate than that which subsists between the latter and the true coal-measures. Another way of stating this is, that there is a constant gain in the number of genera and species, from the Lower to the Upper Devonian, but that at the close of the Devonian, many species and some genera disappear. *In the Lower Carboniferous, the flora is again poor, though retaining some of the Devonian species, and it goes on increasing up to the period of the Middle coal-measures, and this by the addition of species quite distinct from those of the Devonian period."* Is not this acknowledging a continual change in the vegetation of the coal epoch, from its beginning to its end? for we cannot admit of course that according to the views of Professor Dawson, such a change has taken place in the Lower Carboniferous, to stop at once at what he calls the Middle coal-measures. And can we not then conclude that with careful and long researches, at such places where the stratification is perfectly well fixed, these changes of vegetation may be recognized in strata of different horizon, and thus used for comparison at other localities?

The discussion concerning the *true Carboniferous measures* is, as you say, tedious and useless, at least when it is made without comparison with what we have around us. . . . . It is certain that the plants of the red shales (Vespertine or Ponent of Rogers), are different from those of the *coal-bearing* measures. There is, indeed, a gap in the vegetation between the *Red shales* and the Conglomerate, even near their horizontal line of union at Pottsville, while in the West, the true coal vegetation descends as low as the Upper Archimedes limestone, or even lower. This anomaly is to my persuasion merely apparent, or the result of causes without connection with the stratification. The vegetation of the coal must be always considered as a peculiar, and if I can say so, as a local one, born and continued under peculiar influences, and thus without a necessary specific connection with that of the open and dry land; a true peat or bog vegetation. I have many times taken the trouble to compare the vegetation of our peat bogs with that of the country at large, to show how the first one would be insufficient to give us even a slight idea of the last. Now the shales of the Old Red sandstone were evidently formed by open extensive flats, alternately covered with water or left dry, and thus, having a peculiar vegetation far different from that of the Bogs, which were always under the influence of a continual internal and external humidity. Compare, for example, the vegetation of the flats of Holland around Groningue, with that of the peat bogs of the same country, and seen just near the border of the same flats. There is not a single species common to both formations. The same can be said of our coast flats, and in New Jersey, you have the same peculiar difference of vegetation near the shores; the one covering

all the part that is reached by marine water, or rather by the tides; the others beginning in lagoons, where the water ceases to be subjected to alternate changes. Thus it has happened, to my persuasion at least, that there has been formed at some place red sandstone, with peculiar remains of vegetation and coal shales, though inferior in geological horizon with true coal plants. And for this reason, I say, that we have to admit the vegetation of the Old Red and that of the Coal, without putting too great reliance in the data furnished by palæontological botany concerning the age of stratification. But remark that I say this only of the red shales, compared with the coal formation; for indeed, as Professor Dawson says it, the slow change of vegetation in the coal-measures (putting aside the Old Red), is apparent from the lowest coal under the Archimedes limestone, to the highest strata of the coal-measures.

Pending nominations Nos. 481 to 491, and new nominations Nos. 492, 493 were read.

And the Society was adjourned.

Stated Meeting, April 3, 1863.

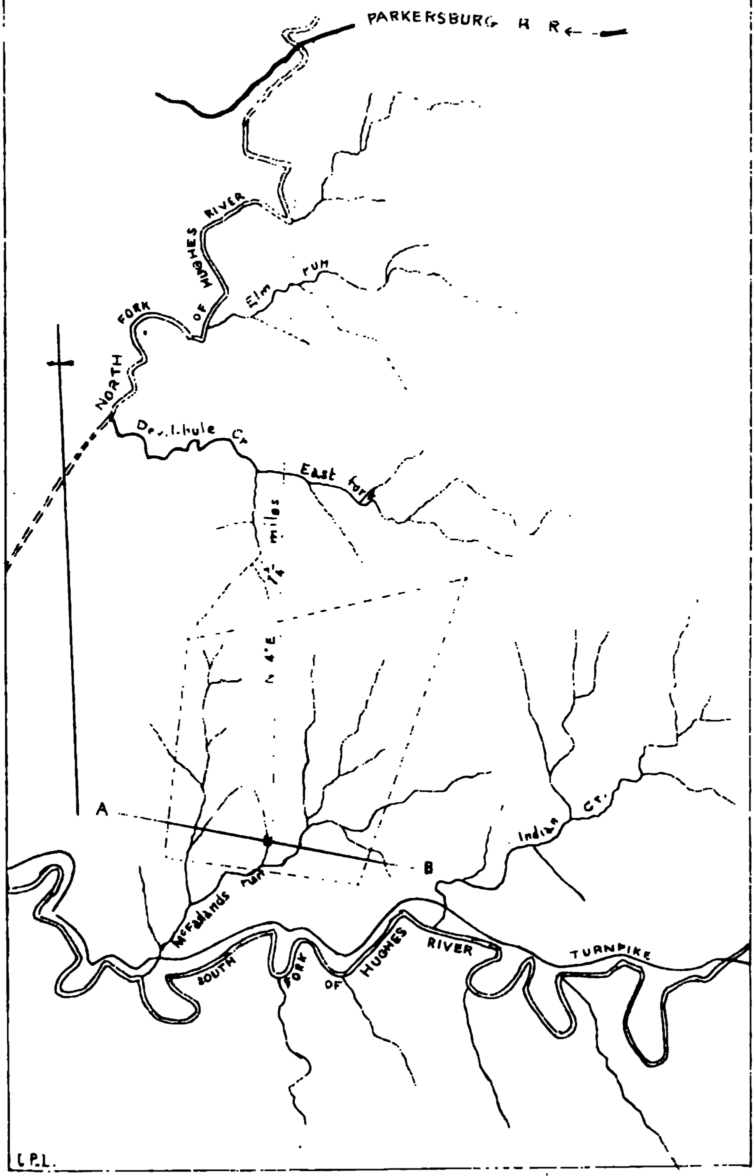
Present, eleven members.

Dr. WOOD, President, in the Chair.

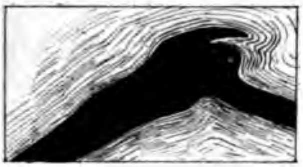
Letters accepting membership were received from F. Forchhammer, dated Copenhagen, March 11th, 1863, and from Max Müller, dated 64 High Street, Oxford, March 14th, 1863.

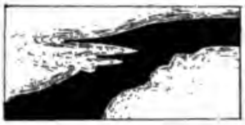
Letters acknowledging the receipt of publications were received from the Royal Society at Upsal, September 15th; the Royal Geographical Society at Vienna, October 15th; the Royal Geological Institute at Vienna, October 4th; the Society at Wiesbaden, November 1st; the Geological Society at London, January 7th; and the Antiquarian Society at Worcester, March 2d, 1863.

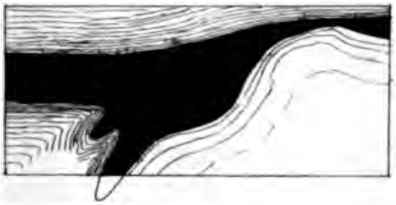
BITUMEN VEIN, W.VA

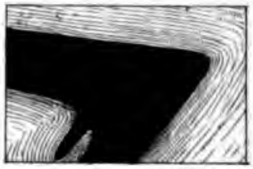


Prospect Colliery, Broad Top.

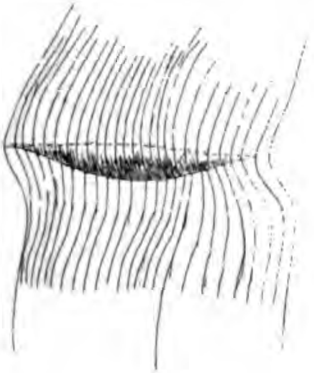


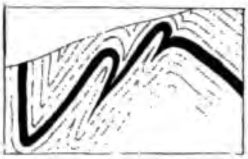


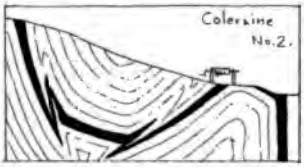


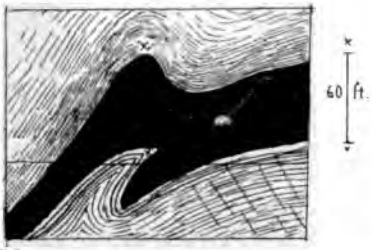


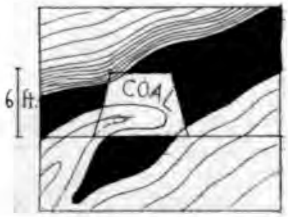
Beaver Meadow Coal Basin.





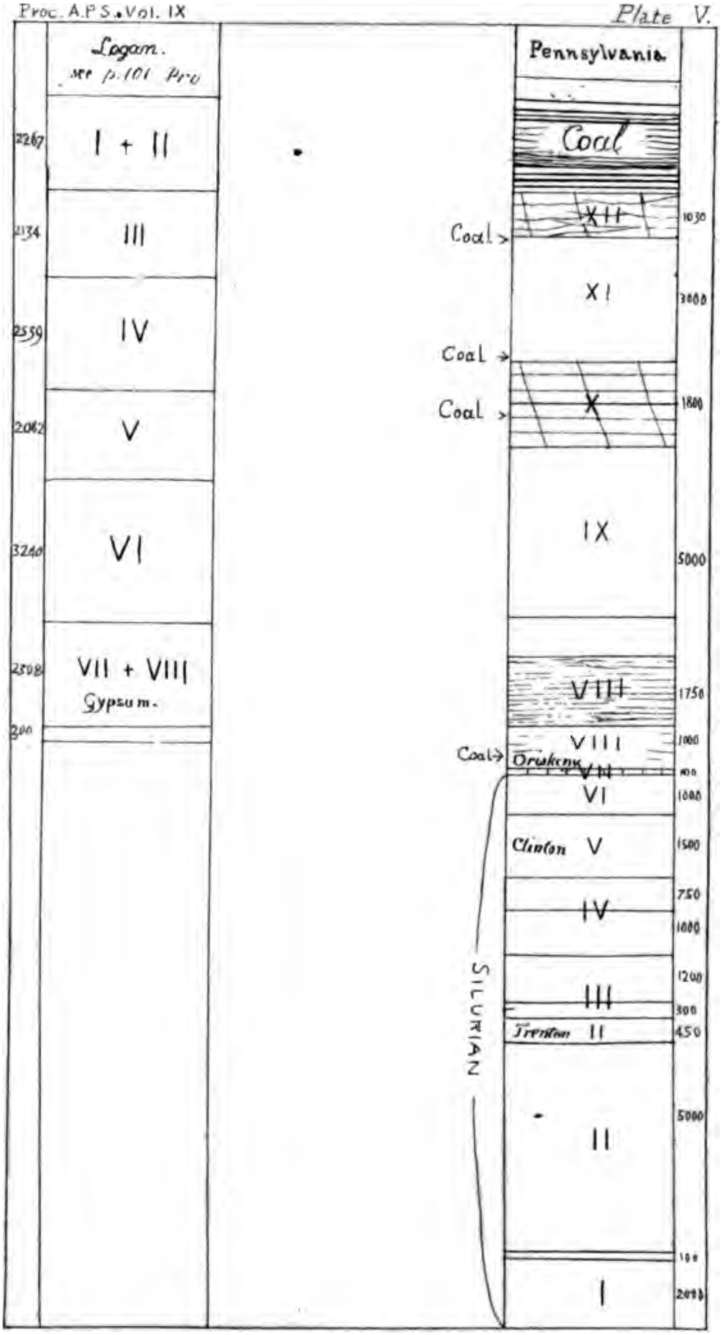






L.B.L.

Plate V.


Logan.
see p. 101 Pro
2267
I + II
2134
III
2559
IV
2062
V
3240
VI
2508
VII + VIII
Gypsum.
300
Pennsylvania
Coal
XII
1030
Coal
XI
3000
Coal
X
Coal
1800
IX
5000
VIII
1750
VIII
1000
Coal
Oriskany
VII
400
VI
1000
Clinton
V
1500
IV
750
1000
III
1200
300
Trenton
II
450
SILURIAN
II
5000
100
I
2000

DESCRIPTION OF LESLEY'S MICROMETER FOR FIELD-NOTE PLOTTING.

(*Read before the American Philosophical Society, April* 18, 1873.)

I desire to place on record in the Proceedings of the Society a description of my Micrometer for plotting field-notes, which appears to be coming into favor with Civil and Mining Engineers.

It was many years ago that the need of such a little instrument forced itself on my attention, as a substitute for a vernier attachment to a scale for use on the office-table. The strain upon the eyes in constant plotting on small scales, say on the common scale of 1000 feet to the inch, or the not uncommon one of 2000, is greater than the best human organs of vision can endure without permanent injury ; to say nothing of the loss of time involved in adjusting the dividers, or applying the paper edge, if a paper scale be used directly. Every field worker who has constructed elaborate contour line maps covering an extensive region of country will bear me out in this assertion.

Considering also the liability to error in counting the decimals and hundredths or thousandths of the scale-unit of *distances*, after hours of application to work has lowered the tone of the nervous system, I sought some mechanical substitute analogous to Mr. Cleaver's Protractor, now in almost universal use for plotting *courses* with ease and precision.

Many forms of such an instrument passed through my mind ; but over occupation, or perhaps laziness, prevented me from taking the necessary steps to realize the idea in even tentative forms, although I spoke of it several times to Mr. Young, the accomplished and experienced instrument-maker of Philadelphia, now dead.

During my wanderings in Europe in search of health in 1866, '67 and '68, I was several times the guest of my old friend and fellow-laborer in the Anthracite coalfields (1853), Prof. Edouard Desor, at his charming residences on the Combe Varin and in Neufchâtel, Switzerland. One day we strolled into the well-known philosophical instrument manufactory of Mr. Hipp, to whom, among other things, I mentioned the need of a Micrometer Divider for plotting, and drew at his request three of its possible forms, such as seemed to me the most feasible, giving him an order for one, and leaving him to select the form he preferred.

On my return to Philadelphia in the spring of 186[illegible] I received it in a broken condition. The chain had been snapped by some custom-house official, too curious to learn its nature to treat it with much delicacy of handling. It was however easily repaired, and I found it all I could desire : handy, accurate in its action, and perfectly relieving the eyes from the strain of measuring. It was much admired by my professional acquaintances, but remained a solitary specimen until Mr. Kerr, State Geologist of North Carolina, begged permission to have it copied at Mr. Young's (Jr.) establishment. This was in the winter of 1871, '72. I have since been informed by Mr. Kerr that his order was never filled; at least, he never received his Micrometer. The original was in constant use by one of my assistants in my office throughout the spring and summer of 1872. When the course of instruction in the new Department of Science of the University of Pennsylvania commenced last fall I accustomed my special geological students to use this instrument among others, and ordered of Heller & Brightly, instrument-makers, a duplicate of it, set however not to centimeters and millimeters, but to inches and hundreths of an inch. While making it, Mr. Eckley Coxe and other civil and mining engineers saw it, and ordered others like it for their own use, and these orders have become so numerous that it has evidently taken its place among the accepted apparatus of the engineer's office-table. I hope many will in future enjoy the relief and comfort from it which I have enjoyed since 1868.

I was urged to patent it, as Mr. Cleaver patented his Protractor. But I feel a natural prejudice against patenting a little thing which may become to some extent a public benefit, at all events within the not altogether narrow limits of one of the scientific professions. I desire, however, to prevent any one else from hampering its progress by a patent, and to that end beg leave to place this record of its invention among the Proceedings of this Society. Any one can obtain the instrument free of patent royalty, from the makers above named, or may order it made for themselues anywhere else.

This Micrometer consists of an arc set with three, four or more needle-points fixed at intervals of one centimeter, one-half inch, or any other unit adopted for the survey, equivalent say to 100 feet (yards, links, rods, &c).

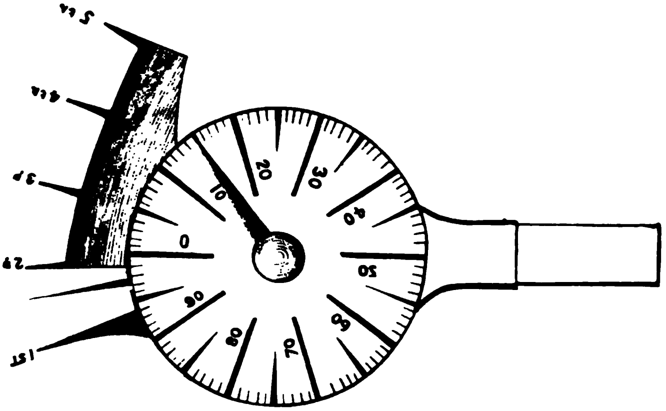
A handle projects upward from the inside of the arc by which to hold it, and by which it may be applied to the line of course and be gently rotated, so that each needle-point in its turn pricks its (100 feet) unit distance along the line.

Between the last two needle-points floats a supernumerary needle-point or compass-leg, jointed high up on the handle, and swung or floated to and fro by a simple ratchet and watch chain, turned at will by means of a button, projecting from the centre of a circular disc on the handle; the disc circle being divided into hundredths (thousandths, &c.,) and traversed by an index which starts from and comes round to a stop at zero.

While the index travels over the disc from 0 to 100 the supernumerary needle-point travels from needle-point to needle-point, one unit.

Example of use: Suppose a distance 327 feet to be laid off on a course; the fifth needle is applied to the station (point of tangent, or point of curve) and the arc rotated, so that the fourth needle pricks 100,

the third 200, the second 300 feet. Then, the index being brought to 27, the floating needle pricks 327. See woodcut, Fig.



Mr. Eckley Coxe has had a useful addition made to his instruments in the shape of a set of removable rings, divided for 100ths, 1000ths, 66ths, 33rds, &c., &c. Two little screws hold the ring in place, whichever one may be in request for any particular plotting. When plotting on the scale of some other unit of distance is required another ring is substituted.

A STUDY OF THE STRUCTURE AND EROSION OF BRUSH MOUNTAIN, IN BLAIR COUNTY, PENNSYLVANIA (WITH A MAP).

By J. P. Lesley,

Professor of Geology in the University of Pennsylvania.

At one of the meetings of the Society in the summer of 1873, a proof copy of the Map of Brush mountain, bound into this number of the Proceedings, was exhibited to the members, and its most interesting features pointed out.

No detailed description of it seems necessary. Those who are conversant with Topography in its application to Geology will find sufficiently plain indications of the state of things at the Tyrone City Gap and along the Little Juniata River, displayed by the ten-foot contour-lines of the topography, and by the three small vertical sections placed near the geographical points where they were made.

The system of thick and thin contour-lines on the dark and light sides of hills, to bring them into relief, is one which I invented about the year 1855, using it on a large scale for the first time in the construction of my elaborate Maps of Fayette and Westmoreland Counties, made for the Pennsylvania Railroad Company. The effect upon the portraiture of five hundred square miles of that strongly accidented country was very fine ; and was obtained without in any measure sacrificing the scientific accuracy of the work. I have pursued the same plan ever since, and teach it in the Geological laboratory of the Scientific Department of the University.

The Map here given is a heliotype reduction to one-third (linear) of the original drawing, made by James Osgood & Co., of Boston. It is therefore a fac simile ; and every error is exhibited. The only one needing designation is of a grave character, and I hope to present a correction of it at some future time. The narrow, straight and deep little valley which heads southwest between the crests of the mountain, and issues northeast at the centre of the Gap, is not straight at its mouth. It bends down stream somewhat, allowing the southeast shoulder of the northwestern ridge to project into the Gap, in the same style as does the southeast crest ridge on the opposite side of the Gap ; only in a reverse direction ; that is, down stream instead of up stream. This may be considered a venial error of detail, but it is not ; for it casts a shadow on the demonstration that the erosion of any one part of Apalachian land-surface relates itself harmoniously with the general erosion of its district ; and yet is differentiated by exceptional parts of structure. The short ravine splitting the mountain on the northeast side of the Gap would have bent southward at its mouth, like the long ravine opposite to it, but for a crush in the red rocks of IV., caused by the same force which has thrown the whole mountain on that side of the river forward (northwestward) about two hundred yards.

This upthrow fault, plainly exhibited by the Map, has undoubtedly determined the point at which the drainage of the Upper Little Juniata River had to pass the outcrop barrier of the vertical measures of IV (Middle Silurian) now constituting the double crested mountain, called Brush Mountain northwest of the Gap, and Bald Eagle Mountain northeast of the Gap.

There are similar faults connected with the issuing points of the Little Juniata and of the main Juniata at their gaps through Tussey Mountain, which forms the descending (S. E.) outcrop of the same measures on the other side of the great anticlinal, ten miles further to the southeast.

THE OUTCROP BELT OF THE EAST KENTUCKY COAL FIELD.

(*To accompany a Map presented to the American Philosophical Society, June 20th*, 1873.)

BY JOSEPH LESLEY,

FORMERLY ASSISTANT ON THE KENTUCKY GEOLOGICAL SURVEY.

Under appointment of David Dale Owen, State Geologist of Kentucky, I began on the 25th of August, 1858, a Geological and Topographical Survey of the margin of the Eastern Coal Field of the State, to determine its area, and the number, thickness and attitude of its beds of coal and iron ore: and to get a reliable base for a future survey of the whole Eastern Coal Field, as far as to the Virginia line.

The base line of my survey was run upon the common roads of the country; flying side lines, and in some cases closed looped lines, being carried out sideways to the western outcrops wherever necessary.

An admirably constructed odometer was used for measuring distances, and a compass with side-telescope and eccentric target for running courses. Aneroid observations, regularly taken at every station, were checked by clinometric measurements made with a vertical circle attached to the telescope; and also by synchronous observations with a barometer stationary in camp.

The main base line was also carefully leveled for a distance of about two hundred miles with a spirit-level, which was also used on some of the side lines, in order to tie the parts of the work together, and to give the exact datum above tide-water for all principal stations, in view of adopting them as starting points of the contemplated survey of the whole coal field.

The work thus described was continued from September 1, 1858, to November 1, 1859, seven months being passed in field work, and with the following results:

1st. A large contour-line map was made on a scale of three miles to the inch, which has never been published. The original plottings were on a scale of five hundred feet to the inch. This map includes only the ground covered by the survey, and shows the positions of towns, county-line crossings, coal openings and other points of interest, as well as the crossings of the long east and west base line run by S. S. Lyon, Assistant on the State Geological Survey.

2d. The map now published for the first time, to accompany this description, was compiled from the survey sheets of the first-named map, from old maps in the Internal Improvement Office, from railway surveys, and from the old State map.

3d. A base line for future use, extending in a general southwest direction along the strike of the formations, beginning at a point five hundred and ninety-seven feet above tide, close by the town of Grayson, in Carter county, Northeast Kentucky, and extending, by a loop embracing a section covered by the Little Sandy River and its tributaries, to the ridge dividing Carter from Rowan counties; thence, across the east end of Bath county to Jeffersonville, in Montgomery County; thence, to the Red River Iron Works on the edge of Estill county; thence, to the town of Proctor and its coal mines on the Kentucky River; thence, across Owsley county to McKee in Jackson county; thence, to Mt. Vernon in Rock Castle county, and Somerset in Pulaski county; thence across the Cumberland River at the "lower ford" to Monticello in Wayne county; and thence, to its southern terminus on the Tennessee State-line in Clinton county, at a point on the waters of Wolf River, one thousand and nineteen feet above tide.

4th. The establishment of sixty-two bench marks, showing elevation above tide and above low water in the Ohio River at Catlettsburg.

5th. An unpublished geological section to accompany Map No. 1.

By observations made during the progress of the work, the following points of scientific interest present themselves:

Coal
on Silurian

1st. In approaching this coal field from Middle Kentucky, over the lower Silurian formations, one is confronted by a belt of cone-shaped hills having the Devonian black slates in their gently sloping bases, upon which rise steeper slopes of the olive-colored shales and overlying grit stones of the same system. These shales and grit stones together vary in thickness from three hundred and fifty to five hundred and fifty feet, the lower and larger division of the formation having disseminated through it nodular masses of earthy iron ore, giving origin to numerous chalybeate springs; the upper division affording valuable building stone.

Upon the above-named rocks lies the Mountain or Sub-carboniferous Limestone, varying in thickness from seventy feet at the north end of the line to four hundred feet and more at the southern end. This formation is composed of alternating layers of white, gray and buff-colored strata, ranging in quality from argillaceous claystone to the purest plaster limestone. The lowest members of the series hold large dark green flint pebbles, and exhibit traces of galena. Dry valleys and numerous caves distinguish this formation.

Above these limestones lies the Millstone Grit formation (the Conglomerate No. XII of the Pennsylvania Survey) in two members; the lower made up of thin sandstones and shales, enclosing beds of coal and iron ore. This is named the "Sub-conglomerate" member, and seems to be the equivalent of Logan's 8th division in Nova Scotia, and of the Yoredale series in England. The upper or "conglomerate" proper consists of a massive, coarse-grained ferruginous sandrock containing pebbles.

The two members of this formation thicken southwestwardly, as do also the rocks of the previously mentioned formations on which they repose, but under different and peculiar conditions.

At Grayson the whole formation measures ninety feet, with the "lowest" coal bed—a mere streak—interpolated between its base and the top of the limestone.

At the north fork of Licking River the upper member is one hundred and fifty feet thick; while the lower one is only eight feet thick and contains a well-defined bed of iron ore and a twelve inch coal-bed.

In Estill county the upper member measures two hundred feet; the lower has also increased to fifty feet, its accompanying ore-bed being now workable, and its coal-bed measuring twenty-seven inches in thickness.

From this last-named point to the south end of the line at the Tennessee State line the peculiar character of this formation shows itself in a marked manner; its lower member increasing to an average thickness of two hundred and twenty-five feet, and containing two workable and three other thin beds of coal and three well-defined horizons of shale containing iron-ore; its upper member nowhere exceeding eighty feet in thickness.

The point of sudden change lies geographically between the top of the ridge dividing the Red and Kentucky Rivers and the valley of the Kentucky river itself.

The "lowest" coal-bed holds its place throughout the belt; the other sub-conglomerate coals, mentioned above, coming in one by one above it; and in proportion to the constant thickening of the lower member of the formation.

Back from the greatly eroded and boldly-rising wall of the Conglomerate, which always marks the western margin of the East Kentucky coal field, lie, thinly spread over a plateau trenched by ravines, the lowest layers of the Lower Coal Measures of Pennsylvania, = the Middle Coal Measures of Nova Scotia, of Dawson.

2d. All the formations mentioned above dip to the southeast, making the western side of a wide and shallow synclinal trough.

3d. This great wave, having its axis in a direction N.N.E. and S.S.W., is itself crossed by undulations of no great height and depth, having their axes W.N.W. and E.S.E. Gentle as those undulations were, they were quite sufficient to determine the principal lines of drainage which issue from the mountain country into the plain.

4th. All the formations examined along the base line thicken, and also rise above sea-level, going towards the southwest.

5th. The lowest sub-conglomerate coal-bed varies in thickness, but is persistent throughout the whole extent of the belt surveyed, a distance of about two hundred miles.

6th. Different species of trees mark the outcrops of the different geological formations. The sugar-tree and other maples and the white oak are characteristic of the base of the Devonian "Knobstone" series. Beech and red cedar grow on the sub-carboniferous limestones. Pine, hemlock, laurel and holly possess the conglomerate cliffs and peaks. Chestnut and oak forests cover the shales and sandstones of the great plateau bordered by the conglomerate bluffs.

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